Section 6

SLOPE ROCKFISH

by
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Executive Summary

Pacific ocean perch

For Pacific ocean perch, we explored the use of a generic rockfish model template developed in a modeling workshop held at the Auke Bay Laboratory in February 2001. The model was constructed with AD Model Builder software. The template is a simple age-structured model with allowance for size composition data that is adaptable to several rockfish species. The data sets used included total catch biomass for the years 1961-2001, size compositions from the fishery for 1963-78 and 1990-99, survey age compositions for 1984, 87, 90, 93, 96 and 99, fishery age composition for 2000, and survey biomass estimates for 1984, 87, 90, 93, 96, 99, and 2001. Several alternate model configurations were evaluated. ABCs from these alternative models ranged 10,860 - 17,770 mt. The base model which had all likelihood emphasis factors set at 1 gave an ABC of 13,190. We recommend that the ABC from this base model be used for the 2002 fishery. While we expect several refinements to the model will be made next year, this ABC is similar to last year's ABC of 13,510, and the model used new data (i.e., updated catch, 2001 trawl survey estimates, and 2000 fishery age compositions). The corresponding reference values for Pacific ocean perch are summarized in the following:

$B_{40\%}$ (mt)	98,790
B_{2002} (mt)	107,070
$F_{40\%}$	0.050
F_{ABC} (maximum allowable)	0.050
ABC (mt; maximum allowable)	13,190

Northern rockfish

For northern rockfish, the age-structured model from last years SAFE was used with updated catch, the addition of 1998 and 1999 fishery age compositions, and the 2001 survey biomass estimate. This model is identical to the rockfish template except for a few minor adaptations. Based on this model the recommended ABC is 4,980 mt. The corresponding reference values for northern rockfish are summarized in the following:

$B_{40\%}$ (mt)	23,330
B_{2002} (mt)	40,070
$F_{40\%}$	0.056
F_{ABC} (maximum allowable)	0.056
ABC (mt, maximum allowable)	4,980

This ABC is the maximum allowable ABC under tier 3. However, the declining stock trend, the weakness of recent recruitment estimates, and uncertainty of survey biomass estimates suggest that precaution is warranted for management of this stock.

Shortraker, rougheye, and other slope rockfish

As in the past, exploitable biomass for shortraker and rougheye rockfish and other slope rockfish was estimated by the unweighted average of the last three trawl survey results, excluding the biomass in the 1-100 m depth stratum. The 1-100 m depth stratum was removed from the estimate because most slope rockfish in this stratum are small juvenile fish younger than the age of recruitment, and thus are not considered exploitable. This results in an exploitable biomass of 66,830 mt for shortraker/ rougheye rockfish and 107,962 mt for other slope rockfish. Applying a combination of F=M and F=0.75M rates results in ABC's of 1,610 mt for shortraker/rougheye rockfish and 5,040 mt for other slope rockfish. Development of an age-structured model for rougheye rockfish was initiated using the rockfish template. However, assessing rougheye rockfish with an age-structured model is still in a very preliminary stage.

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6.1 INTRODUCTION

At least 30 rockfish species of the genus *Sebastes* inhabit waters of the Gulf of Alaska (Eschmeyer et al. 1983), and many are commercially valuable. Since 1988 in this region, the North Pacific Fishery Management Council (NPFMC) has divided these species into three management assemblages based on their habitat and distribution: demersal shelf rockfish, pelagic shelf rockfish, and slope rockfish.

Slope rockfish are defined as those species of *Sebastes* that, as adults, inhabit waters of the outer continental shelf and continental slope of the Gulf of Alaska, generally in depths greater than 150-200 m. In contrast, shelf rockfish inhabit shallower, more inshore waters of the shelf. Based on these criteria, 21 species of rockfish are classified into the slope rockfish assemblage (Table 6-1). The assemblage is dominated by one species, Pacific ocean perch (*Sebastes alutus*), which has historically been the most abundant rockfish in this region and has provided most of the past commercial catch.

Slope rockfish are viviparous, with internal fertilization and release of live young. For most species insemination appears to occur in the fall, and release of larvae occurs during spring and early summer. Identification of the larvae of many species of slope rockfish is not yet possible (Gharrett et al. 2000). Consequently there is considerable uncertainty about the early life history of many species. Slope rockfish are very slow growing and long lived with natural mortality rates usually less than 0.10. Maximum ages differ by species and may be as great as 140 yrs as is the case for rougheye rockfish (*S. aleutianus*).

Few studies have been conducted on the stock structure of slope rockfish. For some species, differences among areas in age composition, growth, fecundity, and prevalence of parasites suggest separate populations at the adult stage (Gunderson 1972; Leaman and Kabata 1987; Moles et al. 1998). Based on allozyme variation, Seeb and Gunderson (1988) concluded that Pacific ocean perch are genetically quite similar throughout their range, and genetic exchange may be the result of dispersion at early life stages. In contrast, preliminary analysis using mitochondrial DNA techniques suggest that genetically distinct populations of Pacific ocean perch exist (A. J. Gharrett pers. commun., University of Alaska Fairbanks, October 2000). Hawkins et al. (1997) and Gharrett and Gray (1998) concluded that that two genetically distinct populations of rougheye rockfish exist with partially overlapping geographic ranges. Currently, genetic studies are underway that should clarify the genetic stock structure of some species of slope rockfish.

In 1991, the NPFMC divided the slope assemblage in the Gulf of Alaska into three management subgroups: Pacific ocean perch, shortraker/rougheye rockfish, and all other species of slope rockfish. In 1993, a fourth management subgroup, northern rockfish, was also created. These subgroups were established to protect Pacific ocean perch and shortraker, rougheye, and northern rockfish (the most sought-after commercial species in the assemblage) from possible overfishing. Each subgroup is now assigned an individual TAC (total allowable catch), whereas prior to 1991, a single TAC was assigned to the entire assemblage. Each subgroup TAC is apportioned to the three management areas of the Gulf of Alaska based on distribution of exploitable biomass.

Amendment 58, which took effect in 1998, prohibited trawling in the Eastern area east of 140 degrees W. longitude. Since most slope rockfish, especially Pacific ocean perch, are caught exclusively with trawl gear, it is possible that the entire Eastern area TAC for some species could be taken in the small area in the Eastern area that will remain open to trawling. Alternative apportionment strategies are currently being evaluated by the Gulf of Alaska Plan Team.

6.2 FISHERY

6.2.1 Historical Background

A Pacific ocean perch trawl fishery by the U.S.S.R. and Japan began in the Gulf of Alaska in the early 1960's (Figure 6-1). This fishery developed rapidly, with massive efforts by the Soviet and Japanese fleets. Catches peaked in 1965, when a total of nearly 350,000 metric tons (mt) was caught. This apparent overfishing resulted in a precipitous decline in catches in the late 1960's. Catches continued to decline in the 1970's, and by 1978 catches were only 8,000 mt.

Detailed catch information for slope rockfish in the years since 1977 is listed in Table 6-2a for the commercial fishery and in Table 6-2b for research cruises. The reader is cautioned that actual catches of slope rockfish in the commercial fishery are only shown for 1988-2001; for previous years, the catches listed are for the Pacific ocean perch complex (a former management grouping consisting of Pacific ocean perch and 4 other rockfish species), Pacific ocean perch alone, or all *Sebastes* rockfish, depending upon the year (see Footnote in Table 6-2). The acceptable biological catches and quotas in Table 6-2 are Gulfwide values, but in actual practice the NPFMC has divided these into separate, annual apportionments for each of the three regulatory areas of the Gulf of Alaska.

Foreign fishing dominated the fishery from 1977 to 1984, and catches generally declined during this period. Most of the catch was taken by Japan (Carlson et al. 1986). Catches reached a minimum in 1985, after foreign trawling in the Gulf of Alaska was prohibited.

The domestic fishery first became important in 1985, and expanded each year until 1991. Much of the expansion of the domestic fishery was apparently related to increasing annual quotas; quotas increased from 3,702 mt in 1986 to 20,000 mt in 1989. In the years 1991-95, overall catches of slope rockfish diminished as a result of the more restrictive management policies enacted during this period. The restrictions included: (1) establishment of the management subgroups, which limited harvest of the more desired species; (2) reducing levels of total allowable catch (TAC) to promote rebuilding of Pacific ocean perch stocks; and (3) conservative in-season management practices in which fisheries were sometimes closed even though substantial unharvested TAC remained. These closures were necessary because, given the large fishing power of the rockfish trawl fleet, there was substantial risk of exceeding the TAC if the fishery were to remain open. Since 1996, catches of Pacific ocean perch have increased again, as good recruitment and increasing biomass for this species have resulted in larger TAC's. Catches of northern rockfish were much less than their TAC in 2000 and 2001: in 2000, as a conservative measure to ensure the TAC was not exceeded, and in 2001 because the maximum allowable bycatch of Pacific halibut was reached in the central Gulf of Alaska for "deep water trawl species", one of which is northern rockfish.

Historically, bottom trawls have accounted for nearly all the commercial harvest of slope rockfish. In recent years, however, a sizeable percentage of the shortraker/rougheye rockfish catch has been taken by longlines, and a sizable portion of the Pacific ocean perch catch has been taken by pelagic trawls. In the years 1993-2000, longline catches on an annual basis have ranged from 30% to 48% of the total Gulfwide harvest of shortraker/rougheye. In 2001, the proportion of shortraker/rougheye caught by longline increased to 58%, the highest percentage yet. Most of the shortraker/rougheye taken on longlines are caught incidentally in the sablefish and halibut longline fisheries. The percentage of the Pacific ocean perch catches taken in pelagic trawls increased from 2-8% during 1990-95 to 14-20% during 1996-98.

Before 1996, most of the slope rockfish trawl catch (>90%) was taken by large factory-trawlers that processed the fish at sea. A significant change occurred in 1996, however, when smaller shore-based trawlers began taking a sizeable portion of the catch in the Central area for delivery to processing plants in Kodiak. The following table shows the percent of the total catch of Pacific ocean perch and northern rockfish in the Central area that shore-based trawlers have taken since 1996[1]:

	Percent of catch taken by shore-based trawlers in the Central area					
	1996	1997	1998	1999	2000	2001
Pacific ocean perch	49	28	32	41	52	42
Northern rockfish	32	32	53	44	73	57

Factory trawlers continued to take most of the catch in the Western and Eastern areas.

6.2.2 Species composition

Detailed species composition data for the "other slope rockfish" and shortraker/rougheye subgroups in the 1992-2000 commercial fishery are available from the domestic observer program (Tables 6-3a and 6-3b). One caveat is that these data are based only on trips that had observers on board. Consequently, they may be somewhat biased toward larger vessels, which had more complete observer coverage. For "other slope rockfish", the percentage data in Table 6-3 can be applied to the commercial catches in Table 6-2a to yield the following Gulfwide estimates of catch in mt for each species:

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Northern rockfish	7,770	-	-	-	-	-	-	-	-
Sharpchin rockfish	434	1,345	330	342	278	316	319	169	274
Redstripe rockfish	261	1,222	207	198	134	291	51	107	51
Harlequin rockfish	745	1,864	789	667	403	492	443	438	186
Silvergrey rockfish	130	487	219	123	8	34	8	19	19
Yellowmouth rockfish	102	498	40	15	6	63	1	2	13
Redbanded rockfish	-	-	23	22	30	15	20	21	25
Other species	2	16	4	31	23	6	21	32	10

These data indicate that for the current subgroup (i.e., excluding northern rockfish), harlequin, sharpchin, redstripe, silvergrey, and yellowmouth rockfish have been the predominant species caught in the commercial fishery. Also, it should be noted that there was a substantial increase in the catch of these five species in 1993, when northern rockfish were removed from the subgroup. Apparently, removing northern rockfish resulted in an expansion in the fishery for the other species. In 1994-1998, however, the estimated catches for all these species decreased considerably, due at least in part to the lower TAC's set for the subgroup in these years. Catches have remained low since 1998 because of the trawl closure that began that year in the eastern Gulf of Alaska. Most of the biomass of "other slope rockfish" species is located in this area, and fishermen have apparently been unsuccessful or not interested in catching these species with non-trawl gear.

[1]National Marine Fisheries Service, Alaska Region, Fishery Management Section, P.O. Box 21668, Juneau, AK 99802-1688. Data are from weekly production and observer reports through October 6, 2001.

For the shortraker/rougheye subgroup, Table 6-3b shows that shortraker rockfish have always predominated in the commercial catch composition, in some years by a substantial margin. This is not surprising, as shortraker rockfish usually have a higher market value than rougheye rockfish.

6.2.3 Bycatch

The only analysis of bycatch in slope rockfish fisheries of the Gulf of Alaska is that of and Ackley and Heifetz (2001). They examined data from the observer program for the years 1993-95. For hauls targeting Pacific ocean perch, the major bycatch species were arrowtooth flounder, shortraker/rougheye rockfish, sablefish, and "other slope rockfish". (This was based only on data for 1995, as there was no directed fishery for Pacific ocean perch in 1993-94.) For hauls targeting on northern rockfish, the principle bycatch species was dusky rockfish, followed by "other slope rockfish". Although regulations called for no directed fishing for shortraker/rougheye rockfish during these years, Ackley and Heifetz (2201) identified some hauls in which these two species were targeted; the major bycatch in these hauls was arrowtooth flounder, sablefish, and shortspine thornyhead.

The bycatch of slope rockfish species in non-rockfish fisheries has not been well documented. As previously mentioned, a substantial portion of the shortraker/rougheye annual catch comes as bycatch in the longline fisheries for Pacific halibut and sablefish. Presumably, some slope rockfish are also taken in flatfish trawl fisheries.

6.2.4 Discards

Gulfwide discard rates[2] (% discarded) for the four slope rockfish management subgroups in the commercial fishery for 1991-2001 are listed as follows:

Year	Pacific ocean perch	Shortraker/ rougheye	Northern rockfish	Other slope rockfish
1991	15.7	42.0	-	20.0
1992	21.5	10.4	-	29.7
1993	79.2	26.8	26.5	48.9
1994	60.3	44.8	17.7	65.6
1995	19.8	30.7	12.7	72.5
1996	17.2	22.2	16.5	75.6
1997	14.3	22.0	27.8	52.1
1998	14.0	27.9	18.3	66.3
1999	13.8	30.6	11.1	68.7
2000	10.7	21.2	8.7	52.8
2001	8.5	29.1	17.5	47.9

The high discard rates for Pacific ocean perch in 1993 and 1994 can be attributed to its "bycatch only" status for most of this time period. Since then, discard rates for Pacific ocean perch have steadily decreased. Relatively high discard rates are also seen for "other slope rockfish" in 1993-2001, after northern rockfish were no longer in the group. Many of the remaining species in this group, such as harlequin and sharpchin rockfish, are small in size and of lower economic value, and there may be less incentive for fishermen to retain these fish. The above table also indicates that discards of shortraker/rougheye have generally been moderate, whereas discards of northern rockfish have been relatively low over the years.

[2]Source: National Marine Fisheries Service, Alaska Region, Fishery Management Section, P.O. Box 21688, Juneau, AK 99802-1688. Data are from weekly production and observer reports through October 6, 2001.

6.3 DATA

6.3.1 Fishery Data

6.3.1.1 Catch

Detailed catch information for slope rockfish is listed in Table 6-2a.

6.3.1.2 Catch Per Unit Effort (CPUE) in the Japanese Trawl Fishery

The Japanese trawl fishery in the Gulf of Alaska provided detailed catch and effort information on Pacific ocean perch for the years 1964-84. These data indicated a steep decline in stock abundance of Pacific ocean perch from 1965 to 1976, and that stocks remained severely depressed in the years 1977-84 (Carlson et al. 1986). This time series of CPUE data ended in 1984 when Japanese trawl fisheries in the Gulf of Alaska were terminated.

6.3.1.3 Age and Size composition

Observers aboard fishing vessels and at onshore processing facilities have provided data on size composition of the commercial catch of slope rockfish. Tables 6-4 and 6-5 summarize the length compositions for Pacific ocean perch and northern rockfish. Figures 6-2 and 6-3 summarize available age compositions for Pacific ocean perch and northern rockfish. The age compositions for northern rockfish for both years 1998 and 1999 indicate the presence of a stronger than average year class between the years 1982 and 1985. The clustering of several larger than average year classes in this period is most likely due to ageing error. A stronger than average year class around the years 1983-1985 is also indicated by the survey age compositions described below.

6.3.2 Survey Data

6.3.2.1 Longline Surveys in the Gulf of Alaska

Two longline surveys of the continental slope of the Gulf of Alaska provide data on the relative abundance of slope rockfish in this region: the earlier Japan-U.S. cooperative longline survey, and the ongoing NMFS domestic longline survey. These surveys compute relative population numbers (RPN's) and relative population weights (RPW's) of rockfish on the slope as indices of stock abundance. Rougheye and shortraker rockfish are the primary rockfish species caught. The results for both surveys concerning rockfish, however, should be viewed with some caution, as the analyses do not take into account possible effects of competition for hooks with other species caught on the longline.

The cooperative longline survey was conducted annually during 1979-94, but RPN's for rockfish are only available for the years 1979-87 (Sasaki and Teshima 1988). These data are highly variable and difficult to interpret, but suggest that abundance of rougheye and shortraker rockfish remained stable in the Gulf of Alaska (Clausen and Heifetz 1989). The data also indicate that rougheye and shortraker rockfish are most abundant in the eastern Gulf of Alaska.

The domestic longline survey has been conducted annually since 1988, and RPN's and RPW's have been computed for each year (Table 6-6[3]). For rougheye rockfish, Gulfwide RPN values from this survey have ranged from a low of ~13,000 in 1988 to a high of ~39,000 in 2000; for shortraker rockfish, Gulfwide RPN’s have ranged from a low of ~11,000 in 1994 to a high of ~32,000 in 2000. Similarly, lowest and highest Gulfwide RPW values for each species were in these same years. Definite trends in these data over the years are difficult to discern, and the fluctuations in RPN and RPW may reflect random variations in the survey's catch rates, rather than true changes in abundance. It should be noted, however, that the five highest annual Gulfwide RPN’s and RPW’s for shortraker rockfish were in the most recent five surveys, in the years 1997-2001. Relatively high RPN’s and RPW’s for rougheye rockfish are also seen in these years. Similar to the cooperative longline survey, the domestic survey results show that abundance of shortraker and rougheye rockfish is highest in the eastern Gulf of Alaska: the Yakutat area consistently has the greatest RPN and RPW values for shortraker rockfish, and the Southeastern area is usually the best for rougheye rockfish.

6.3.2.2 Biomass Estimates from Trawl Surveys

Bottom trawl surveys were conducted on a triennial basis in the Gulf of Alaska in 1984, 1987, 1990, 1993, 1996, and 1999, and these surveys became biennial in 2001. The surveys provide much information on slope rockfish, including estimates of absolute abundance (biomass), age composition, and growth characteristics. The triennial surveys covered all areas of the Gulf of Alaska out to a depth of 500 m (in some surveys to 1,000 m), but the 2001 survey did not sample the eastern Gulf of Alaska. Other, less comprehensive trawl surveys were periodically conducted before 1984 in the Gulf of Alaska, and these have also provided information on age and size composition of slope rockfish. Summaries of biomass estimates from the 2001 trawl survey and comparative estimates from the 1984 to 2001 surveys are provided in Tables 6-7 and 6-8, respectively.

6.3.2.2.1 2001 Biennial Trawl Survey

As noted above, the 2001 trawl survey, in contrast to all the previous triennial surveys, did not cover the eastern Gulf of Alaska. Consequently, biomass estimates for slope rockfish from this survey are only available for the western and central Gulf of Alaska, and these estimates are listed in Table 6-7. Although the eastern Gulf of Alaska was not sampled in 2001, in Table 6-7 we have included substitute estimates of slope rockfish biomass for this region (the Yakutat and Southeastern statistical areas). This allows continuation of the time series of Gulfwide biomass estimates from all the surveys. Two basic approaches were considered to estimate these substitute biomass values for the eastern Gulf of Alaska: a value based on a correspondence with past biomass trends in the western and central Gulf, or a value based only on past eastern Gulf survey estimates. The first approach assumes that there is a proportional relationship between the abundance in each area, that the changes are measured by the trawl survey, and that the abundance in the eastern Gulf can be predicted by the proportional relationship. The second approach makes none of these assumptions, but assumes only that the average of past survey results is a reasonable value to use for 2001. The two approaches were compared for four major species of rockfish (Pacific ocean perch, and shortraker, rougheye, and dusky rockfish) by attempting to predict past eastern Gulf survey results using prior information on all areas for the first approach and using only prior information for the eastern Gulf for the second approach. Neither approach was consistently better than the other. Rather than use a different method for the various species, we recommend using the consistent, simple approach of averaging of the three most recent biomass estimates for the eastern Gulf from the 1993, 1996, and 1999 surveys to compute

[3] M. Sigler, National Marine Fisheries Service, Alaska Fisheries Science Center, Auke Bay Laboratory, 11305 Glacier Hwy., Juneau AK 99801. Pers. commun. September 2001.

biomass estimates for this region in 2001. These averages are those listed in Table 6-7 for the eastern Gulf in 2001.

The 2001 trawl survey indicated that Pacific ocean perch was by far the most abundant species in the slope rockfish assemblage, with an estimated Gulfwide biomass of 858,982 mt, or 61.9% of the assemblage total (Table 6-7). Within the area actually sampled in the survey (Shumagin, Chirikof, and Kodiak areas), Pacific ocean perch comprised 63.1% of the slope rockfish biomass. Northern rockfish was the second most abundant species; it comprised 25.6% of the estimated Gulfwide biomass, and 31.5% of the slope rockfish biomass in the area actually sampled in the survey. The 2001 survey did an especially poor job of sampling species in the “other slope rockfish” management subgroup because it did not cover the eastern Gulf of Alaska, where most of the biomass for these species is located.

The biomass estimates for Pacific ocean perch and northern rockfish in 2001 were both greatly influenced by extremely large catches in one or two hauls. Two hauls in the Shumagin area had catches for Pacific ocean perch of ~6 mt each, and the very high biomass there for this species can be mostly attributed to these hauls. Likewise, one haul in the Kodiak area produced the largest catch of northern rockfish (nearly 14 mt) that has ever been encountered in the trawl surveys, and it also resulted in an extremely large biomass estimate. This anomalously high catch explains the high variance and resultant broad confidence interval for Gulfwide biomass of northern rockfish shown in Table 6-7.

6.3.2.2.2 Comparison of Trawl Surveys in 1984, 1987, 1990, 1993, 1996, 1999, and 2001

Gulfwide biomass estimates from each of the trawl surveys are listed in Table 6-8 for all species of slope rockfish. Gulfwide biomass estimates and 95% confidence intervals are also shown graphically in Figure 6-4 for the assemblage’s four most important commercial species. The 1984 survey results should be treated with some caution, as a different survey design was used in the eastern Gulf of Alaska. Also, much of the survey effort in 1984 and 1987 was by Japanese vessels that used a very different net design than what has been the standard used by U.S. vessels throughout the surveys. To deal with this problem, fishing power comparisons of rockfish catches have been done for the various vessels used in the surveys (for a discussion see Heifetz et al. 1994). Results of these comparisons have been incorporated into the biomass estimates listed here, and the estimates are believed to be the best available. Even so, the reader should be aware that use of Japanese vessels in 1984 and 1987 does introduce an element of uncertainty as to the standardization of these two surveys.

The biomass estimates for most species have often been highly variable from survey to survey. One extreme example of this is harlequin rockfish, whose biomass estimate increased from 2,442 mt in 1984 to 63,833 mt in 1987, and then decreased to 17,194 mt in 1990. Such wide fluctuations in biomass do not seem reasonable given the slow growth and low natural mortality rates of all *Sebastes* species; in the particular case of harlequin rockfish, fishing mortality was also considered to be very low over the period of these surveys. Large catches of aggregating species, such as Pacific ocean perch or northern rockfish, in just a few individual hauls can greatly influence biomass estimates and may be a source of much variability. Anomalously large catches have especially affected the biomass estimates for these two species in the 2001 survey (see Section 6.3.2.2.1 above) and the 1999 survey (Heifetz et al. 1999). In past SAFE reports, we have also speculated that a change in availability of rockfish to the survey, caused by unknown behavioral or environmental factors, may explain some of the observed variation in biomass. It seems prudent to repeat this speculation in the present report, while acknowledging that until more is known about rockfish behavior, the actual cause of changes in biomass estimates will remain the subject of conjecture.

Biomass estimates of Pacific ocean perch were relatively low in 1984 to 1990, increased markedly in both 1993 and 1996, and remained relatively high in 1999 and 2001. To examine these changes in more detail, the biomass estimates for Pacific ocean perch in each statistical area, along with Gulfwide 95% confidence intervals, are presented in Table 6-9. The large rise in 1993, which the confidence intervals indicate was statistically significant compared with 1990, was primarily the result of big increases in biomass in the Central and Western Gulf of Alaska. The Kodiak area increased greater than ten-fold, from 15,221 mt in 1990 to 154,013 mt in 1993. The 1996 survey showed continued biomass increases in all areas, especially Kodiak, which more than doubled compared with 1993. In 1999, there was a substantial decline in biomass in all areas except Chirikof, where a single large catch caused a very large estimate. In 2001, the biomass estimates in both the Shumagin and Kodiak areas were the highest of all the surveys. In particular, the biomass in Shumagin was much greater than in previous years; as discussed previously, the increased biomass here can be attributed to very large catches in two hauls. The large biomass in Kodiak in 2001, however, appears to be the result of a number of large or moderately large catches. Although the eastern Gulf of Alaska was not sampled in 2001, the biomass for the western and central areas in 2001 totals 712,077 mt. This value nearly equals the Gulfwide biomass estimates in 1996 and 1999; if the eastern Gulf had been sampled in 2001, the Gulfwide biomass estimate for Pacific ocean perch almost certainly would be higher than in any previous survey.

The trends in the estimated biomass of the other species are quite variable (Table 6-8 and Figure 6-4). Of all the major species, biomass estimates for rougheye rockfish have been the most constant from survey to survey. The estimates for northern rockfish were generally similar for the years 1987-1996, but increased greatly in 1999 and 2001. The biomass for northern rockfish in the latter two surveys would have been much less, except for a single large catch in each survey. Both harlequin and sharpchin rockfish have shown large fluctuations in biomass between the surveys. To a lesser extent, the biomass of shortraker rockfish has also varied considerably. The estimates for shortraker rockfish are especially uncertain, as the major habitat for this species, the 300-500 m depth stratum on the continental slope, is largely untrawlable using the survey's nets. The biomass estimate of silvergrey rockfish consistently increased in each survey from 1984 to 1999, and in the latter year was nine times greater than it was in 1984. As noted previously in Section 6.3.2.2.1, the 2001 survey results are of limited value for determining biomass trends of species in the "other slope rockfish" management subgroup because the survey did not sample the eastern Gulf of Alaska, where most of the abundance of these species is found.

The precision of the biomass estimates for the four most valuable species in the assemblage is shown by the confidence intervals depicted in Figure 6-4. Especially noteworthy are the very large confidence limits for Pacific ocean perch in 1999 and northern rockfish in 1999 and 2001. These confidence limits are much greater than in any of the previous surveys, and indicate that the point biomass estimates associated with these years should be viewed with considerable caution.

6.3.2.3 Survey Size Compositions

Gulfwide population size compositions for Pacific ocean perch, northern rockfish, rougheye rockfish, and shortraker rockfish in the 1990 through 2001 trawl surveys are shown in Figures 6-5 through 6-8. The size composition for Pacific ocean perch in 2001 was bimodal, which differed from the unimodal compositions in 1993, 1996, and 1999. The 2001 survey showed a large number of relatively small fish, ~30 cm fork length, together with another mode at ~38 cm. The 30 cm mode is not apparent in any of the surveys before 2001, and may indicate that some recruitment is occurring. The northern rockfish size compositions are all unimodal, with no indication of recruitment of small fish. The compositions are especially similar in 1996, 1999, and 2001, when mean population lengths were nearly identical at 37-38 cm. The size compositions of rougheye rockfish in 1993, 1996, 1999, and 2001 indicated that a sizeable portion of the population each year was <30 cm in length, which suggests that at least a moderate level of recruitment has been occurring during this period. The 1993, 1996, and 2001 compositions were all skewed to the right, with a mode of about 42-44 cm. All the shortraker rockfish size compositions have been unimodal, with almost no fish caught <40 cm in length. Mean length of shortraker rockfish declined from 61.0 cm in 1990 to 57.3 in 1999. Mean length of shortraker rockfish also apparently declined in 2001, but this may be an artifact of the lack of survey coverage this year in the eastern Gulf of Alaska. Previous Gulfwide trawl surveys (e.g., Martin and Clausen 1995; Martin 1997) have shown shortraker rockfish to be larger in the eastern Gulf of Alaska.

6.3.2.4 Survey Age Compositions

Age composition data are available for Pacific ocean perch and northern rockfish from a number of surveys (Tables 6-10 and 6-11 and Figure 6-9). In the following, we summarize age data for Pacific ocean perch and northern rockfish from the surveys. Recently, NMFS age readers have determined that aging of rougheye rockfish can be moved into a production mode, and available age data for this species are being incorporated into development of an age-structured model (see Section 6.6.3). Experimental aging of shortraker rockfish is in progress, but has not yet moved into a production mode.

6.3.2.4.1 Pacific Ocean Perch

The age compositions from the 1984, 1987, and 1990 surveys showed that although the fish ranged in age up to 78 years, most of the population was relatively young; mean population age was 10.1 years in 1987 and 9.8 in 1990 (Clausen and Heifetz 1989; Heifetz et al. 1993). All three surveys identified a relatively strong 1976 year class and also showed a period of very weak year classes prior to 1976. The weak year classes of the early 1970's may have delayed recovery of Pacific ocean perch populations after they were depleted by the foreign fishery. The 1987 age compositions indicated that in addition to 1976, the 1980 year class was also especially prominent. The 1990 age data, however, showed an unexceptional 1980 year class, and suggested the 1986 year class may have been strong. The 1993, 1996 and 1999 surveys verified that the 1986 year class was exceptionally strong. Recruitment of the strong 1986 year class probably accounted for much of the increase in the estimated biomass for Pacific ocean perch in the 1993 and 1996 surveys.

6.3.2.3.2 Northern Rockfish

Age composition data for northern rockfish are available from the 1984, 1987, 1990, 1993, 1996, and 1999 triennial trawl surveys (Figure 6-9). Age results from all six surveys showed that although the maximum age of northern rockfish was much less than that of Pacific ocean perch, the overall population was considerably older. Mean age of northern rockfish in the surveys has consistently increased from 13.1 years in 1984 to 18.6 years in 1999. The age compositions from each survey indicate that recruitment of northern rockfish is highly variable. Several surveys (1984, 1987, 1990, and 1996) show especially strong year classes from the period around 1975-77, although they differ as to which specific years were greatest, perhaps due to aging errors. The 1993, 1996, and 1999 age compositions also indicate the 1983-85 year classes may be stronger than average which is in agreement with recent age compositions obtained from the commercial fishery described above.

6.5 ASSESSMENT PARAMETERS

6.5.1 Natural Mortality, Maximum Age, Age of Recruitment, and Age and Size at 50% Maturity

Estimates of total mortality (Z) and natural mortality (M), maximum age, and recruitment age are shown in Table 6-12. Estimates of Z which were based on catch curves should be considered as upper bounds for M. Estimates of Z for Pacific ocean perch in Archibald et al. (1981) were from populations considered to be lightly exploited and thus are considered reasonable estimates of M. The method of Alverson and Carney (1975) was used to estimate an M of 0.06 for northern rockfish (Heifetz and Clausen 1991). McDermott (1994) used the gonad somatic index method to estimate a range of M for shortraker and rougheye rockfish.

Previously, age and size of maturity information for slope rockfish in the Gulf of Alaska was only available for Pacific ocean perch, and this information was over 20 years old and based on now obsolete aging methods. Recently, new information on female age and size at 50% maturity has become available for Pacific ocean perch, northern rockfish, and sharpchin rockfish from a study in the Gulf of Alaska that is based on the currently accepted break-and-burn method of determining age from otoliths[4]. These new data are summarized below (size is in cm fork length and age is in years):

Species	Management area	Sample size	Size at 50% maturity	Age at 50% maturity
POP	Gulfwide	802	35.7	10
Northern	Central	77	36.1	13
Sharpchin	Eastern	164	26.5	10

6.5.2 Length and Weight at Age

Length-weight coefficients and Von Bertalanffy parameters are shown in Tables 6-13a and 6-13b.

6.6 ANALYTIC APPROACH

Pacific ocean perch and northern rockfish are the only species of slope rockfish which are currently assessed using a formal modeling approach. All other species of slope rockfish are assessed based on trawl survey data. Courtney et al. (1999) presented a stock assessment model for northern rockfish using AD Model Builder software. This is the second year that this model will be used for the assessment of northern rockfish.

For the first time, we present results for Pacific ocean perch based on an age-structured model using AD Model Builder software. Previously the stock assessment was based on an age-structured model using stock synthesis. The assessment model used this year for Pacific ocean perch is a rockfish model template developed in a modeling workshop held in February 2001[5]. The rockfish model template is a modification of the northern rockfish model used in last year's assessment (Courtney et al., 1999). Four changes were made to the northern rockfish model during construction of the rockfish template. Fishery age compositions and associated likelihood components were added. The spawner recruit relationship was removed from the estimation of beginning biomass (B_0). Survey catchability, *q*, was computed relative to survey selectivity standardized to a maximum of one (full selectivity), rather than to survey selectivity standardized to an average of one (average selectivity). The penalties for deviations from reasonable fishing mortality

[4] C. Lunsford, National Marine Fisheries Service, Alaska Fisheries Science Center, Auke Bay Laboratory, 11305 Glacier Hwy., Juneau, AK 99801. Pers. Commun. July 1997.

[5] Rockfish Modeling Workshop, NMFS Auke Bay Laboratory, 11305 Glacier Hwy., Juneau, AK. February, 2001.

parameter estimates were modified. These fishing mortality deviation and regularity penalties are part of the internal model structure and are designed to speed up model convergence. The result is a simple age-structured model with allowance for size composition data that is adaptable to several rockfish species. The results of the rockfish model template fits to Pacific ocean perch and northern rockfish fishery and survey data are summarized below. Enhancements to the rockfish model template and data requirements for use with rougheye rockfish are also summarized.

6.6.1 Pacific ocean perch

6.6.1.1 Model Structure: Application of Rockfish Model Template

In this section we explore the use of the rockfish template for application to Pacific ocean perch in the Gulf of Alaska. For ease in interpretation and to make the assessment amenable to the template not all data previously used in the stock synthesis model were used. The data sets used include total catch biomass for the years 1961-2001, size compositions from the fishery for 1963-78 and 1990-99, survey age compositions for 1984, 87, 90, 93, 96 and 99, fishery age compositions for 2000, survey biomass estimates for 1984, 87, 90, 93, 96, 99, and 2001. Ageing error and standard errors of survey estimates of abundance were included in the model. Note that this is the first time fishery age composition data have been used. Excluded from the model were fishery CPUE for 1964-79, survey age compositions based on surface reading of otoliths (biased ages) for 1963-67, 78, and 79 and based on "break and burn" (imprecise ages) age compositions for 1980-82. These excluded data were generally older and of uncertain reliability. Both survey and fishery selectivity patterns were assumed to be constant over time. Inclusion of fewer data sets and constraints on selectivity enabled easier exploration of model behavior and sensitivity.

6.6.1.2 Base model

Our base model was run with all data components given a likelihood weight of 1 and both survey and fishery selectivity patterns constrained to be approximately asymptotic. As described in Courtney et al. (1999), within a data component likelihood weights were based on sample sizes of (i.e., relative number of hauls) for size and age composition data. We focused on trying to understand how the various data components influence our perception of stock status. Figure 6-10 summarizes the results from the base model. For this base model the fit to survey biomass was poor for the more recent surveys. In addition the fits to some of the survey age compositions was not very good (Figure 6-11). We surmise that this is due to fishery size composition being in discord with some other data components including survey biomass estimates (Figure 6-12). Also note from Figure 6-12 that survey biomass emphasis weights of 1-5 all gave similar values for the overall likelihood and improved the fit to all data components except for fishery size composition. The likelihood component for survey size composition has a large influence on model fits because of the long time series of size composition data. The model uses size composition data by applying a size to age transition matrix.

6.6.1.3 Model Selection

We compare stock assessment results for 5 different model configurations and a projection with updated catch from last year's stock synthesis model.

Model 1 - base model, all emphasis weights equal 1

Model 2 - survey biomass emphasis weight increased to 5

Model 3 - fishery size composition emphasis weight decreased to 0.5

Model 4 - survey *q* fixed at 2.9, similar to value from last year's assessment

Model 5 - asymptotic constraint on fishery selectivity relaxed

Model 6 - projection from last year's stock synthesis model with updated catch

A comparison of model results is summarized in the following:

Likelihood Component	Model					
	1 Base	2 Survey biomass emphasis = 5	3 Fishery size emphasis = 0.5	4 Survey q fixed at 2.9	5 Domed fishery selectivity	6 Projection
	-ln likelihood					
Catch	0.03	0.03	0.03	0.02	0.03	NA
Survey Biomass Index	10.69	9.02	9.63	14.49	10.81	NA
Fishery Age Comp	19.70	16.30	13.79	17.12	20.35	NA
Survey Age Comp	84.02	81.87	70.52	75.37	84.80	NA
Fishery Size Comp	191.93	201.39	225.90	199.03	186.65	NA
Total (unwewighted)	306.37	308.62	319.87	306.03	302.65	NA
Survey *q*	1.04	0.99	1.41	2.89	1.01	2.99
$B_{40\%}$ (mt)	98,790	122,500	91,820	99,300	100,050	110,120
Current female spawning biomass (mt)	107,070	141,340	88,680	108,190	109,700	96,100
$F_{40\%}$	0.050	0.050	0.050	0.054	0.061	0.078
F_{ABC}	0.050	0.050	0.048	0.054	0.061	0.070
ABC (mt)	13,190	17,770	10,860	13,230	13,200	14,270

Models 1, 2, 4, and 5 have similar total likelihoods thus the overall fit to the data is about the same for these models. Model 3 has a poorer overall fit because the down weighted emphasis on size composition resulted in a significantly poorer fit to size composition data. The stock trend was increasing for all models except Model 4. Current spawning biomass is estimated to be greater than $B_{40\%}$ for Models 1, 2, 3, and 4.

The base model predicted the 1976-77, 1980, 1986 year classes were relatively strong, similar to that predicted in last year's assessment (Figure 6-10). There is considerable uncertainty (i.e. wide confidence limits) for the more recent classes (1994-2001 year classes). Note that the fit to survey biomass is poor for the last three surveys. From a low of about 50,000 mt in 1979 - 1984 spawning biomass has been steadily increasing. Full selection to the survey was estimated to be age 7. Full selection to the fishery is at age 8.

We selected the results from Model 1, the base model, as the basis for our recommendations for ABC and overfishing. While we expect several refinements to the model to be made for next year's assessment, the spawning biomass and ABC are similar to the projection from last year's assessment and the model used new data (i.e., updated catch, 2001 trawl survey estimates, and 2000 fishery age compositions). Estimates of the time series of female spawning biomass, biomass (age 6 and greater), catch/biomass, and number of age two recruits are shown in Table 6-14. These estimates are also shown for last year's assessment. The major difference in results between last year's and this year's assessment is that in this year's assessment current spawning biomass is estimated to be above $B_{40\%}$. Last year's assessment indicated a rather steep increase in biomass from a very low level rather than a gradual increase from a moderately low level in the current assessment. This steep increase can be attributed to the above average 1988, 1990, 1992 year classes that were previously estimated. In this year's assessment these year classes were estimated to be below average. A summary of the base model estimates of age composition, fishery and survey selectivity, maturity at age, and weight at age is in Table 6-15.

6.6.2 Northern Rockfish

6.6.2.1 Model Structure

The stock assessment for northern rockfish is based on the same age-structured model used in last years stock assessment, except that fishery age compositions and associated likelihood components were added. The model was constructed using AD Model Builder and was described in detail in an earlier SAFE report (Courtney et al. 1999). The model was fit to available fishery catch and size composition data and triennial trawl survey age compositions. Catch was interpolated for missing years (Courtney et al. 1999). For the first time, the model was fit to newly available fishery age compositions (Figure 6-3). Trawl survey biomass estimates were incorporated as an auxiliary index of abundance. Similar to the Pacific ocean perch assessment the survey biomass estimates were used as an indices of abundance by estimating the parameter q:

Expected Survey Biomass = q*(Estimated Total Biomass)

Natural mortality was fixed at an independently estimated value of 0.06 (Table 6-12) and a single selectivity was assumed for the fishery and the survey. Recruitment variability each year, fishing mortality variability each year, and selectivity at age were also constrained from within the overall model likelihood function, and ageing errors were incorporated into age-error and age-length transition matrices. The log parameters were estimated rather than parameters on the original scale for reliability in the estimation process (Kimura 1989, 1990). Additional structure was added to the model by incorporating a stock recruit relationship (Courtney et al. 1999). Recruitment variability around the stock recruitment relationship was incorporated by estimating recruitment deviations.

Prior distributions were incorporated as penalties in the overall model likelihood for initial values of recruitment variability, survey catchability, and steepness of the stock recruitment relationship (Courtney et al. 1999). It was assumed that the initial values and their prior distributions were similar for northern rockfish and Pacific ocean perch in the Gulf of Alaska.

6.6.2.2 Model Selection

Courtney et al. (1999) found that the model fit the age composition and biomass index poorly and did not satisfactorily describe the population structure. An examination of several alternative model likelihood weights revealed that the most likely cause of the poor fit was an apparent inconsistency in the data between the age and length compositions. In particular, the length compositions were composed of a single mode that progressed in size through time. The model interpreted this mode as a single very large year class, 1976, which dominated the population dynamics of the model. Alternatively, the age composition was composed of several less clearly defined modes which progressed in age through time. An alternative case was obtained by forcing the model to fit the age composition data. In this case, the model estimated several strong year classes and the fishery/survey selectivity curve appeared to be more reasonably defined. The alternative case from 1999 was the preferred model (Courtney et al. 1999) and was implemented for this years assessment with the modifications described below. New data added for this assessment includes the biennial 2001 survey biomass estimate and updated catch from the 2000 and 2001 fishery.

As done last year, the model fit to survey age composition was improved by increasing the survey age composition likelihood weight from one to ten. Increasing the weight forced the model to fit the survey age data in a manner analogous to the method used for the alternate case from 1999. The actual value chosen for the weighting term was based upon a sensitivity analysis (Figure 10 in Courtney et al. 1999). The sensitivity test suggested that a weighting value of ten was just as effective at fitting the age data as the higher weight of fifty used in the 1999 alternative case model, but that the lower weight had less of an impact on the model's fit to the other data.

As done last year, the maximum age for which selectivity at age is estimated was reduced from age 23+ to age 11. Selectivity at age from ages 12 through 23+ were set equal to that of age 11. The choice of age 11 as the maximum selected age was based upon results of the alternate case model from 1999 (Figure 12 in Courtney et al. 1999). The model showed a local peak in selectivity at age 11 and values ranging above and below the peak after age 11. This behavior suggested an asymptote in selectivity at age 11. A test of model sensitivity to the choice of maximum selected age (ranging from 8 to 14) showed little effect on the population (projected catch in 2001 varied only 6% over the range of values). In this year's assessment, the resulting values estimated for selectivity at age followed a logistic growth pattern with a maximum selectivity at age 11 without assuming a functional relationship between selectivity and age.

In the 1999 model, the number of hauls used to collect fishery length and survey age data were used as weighting terms in the multinomial likelihoods due to fishery size and survey age respectively. The purpose of these weighting terms was to reduce the influence of data collected from a relatively low number of hauls in any given year (for example, 6 in the 1984 age compositions, Table 13B in Courtney et. al. 1999). However, there were generally more hauls observed for fishery length data than for survey age data, and consequently more weight was given to length compositions than to age compositions using this weighting scheme. As done last year, the problem was addressed by scaling the number of hauls for fishery length and age data and for survey age data to a maximum of one hundred. Last years assessment incorrectly stated that the number of hauls for fishery length data and survey age data was scaled to a maximum of one. The number one hundred was chosen in order to keep the scale of the sample sizes on the same order of magnitude as the unscaled sample sizes which ranged from 6 to 176 hauls.
Five variations of the northern rockfish model were evaluated for this years assessment. The five models represent changes made to last years northern rockfish assessment model during development of an age-structured rockfish model template[6]. Model 1 is the northern rockfish model from last years assessment. Model 2 is Model 1with the addition of 1998 and 1999 fishery age composition data and associated model likelihood components for the additional data. Model 3 is Model 2 after removal of the spawner recruit relationship from the estimation of beginning biomass (B_0). Model 4 is the same as Model 3 except that survey catchability, q, was computed relative to a survey selectivity standardized to a maximum of one (full selectivity), rather than to a survey selectivity standardized to an average of one (average selectivity). Model 5 is the same as Model 4 except that the penalties for deviations from reasonable fishing mortality parameter estimates were modified. These fishing mortality deviation and regularity penalties are part of the internal model structure and are designed to speed up model convergence. They should not affect model results. Model 5 is the rockfish model template except that the weighting terms are tuned to northern rockfish assessment model used last year.

Model 1 The equivalent to last years northern rockfish assessment model with updated data

[6]Rockfish Modeling Workshop, NMFS Auke Bay Laboratory, 11305 Glacier Hwy., Juneau, AK. February, 2001.

Model 2 Model 1 with the addition of fishery age compositions and associated likelihood components

Model 3 Model 2 with the removal of the spawner recruit relationship estimate of B_0

Model 4 Model 3 with survey catchability, *q*, estimated relative to standardized selectivity

Model 5 Model 4 with reformulated penalties for fishing mortality deviations and irregularity

A comparison of selected likelihood components and results from the 5 model runs follow:

	Model				
Selected likelihood components	1	2*	3	4	5
Catch	0.01	0.01	0.01	0.01	0.01
Survey biomass index	6.30	6.25	6.25	6.03	6.03
Fishery age comp	0.00	16.38	16.38	16.36	16.36
Survey age comp	29.51	29.47	29.47	29.50	29.50
Fishery size comp	128.23	128.65	128.65	128.58	128.58
Recruitment deviations	20.32	20.76	20.76	20.89	20.89
Total (unweighted)	184.37	201.52	201.52	201.37	201.37
Selected model results					
Survey *q*	0.44	0.44	0.44	0.53	0.53
(Spawning biomass 2001)/(Spawning biomass 2000)	0.97	0.97	0.97	0.97	0.97
(Spawning biomass 2001)/(Spawning biomass 1977)	1.67	1.69	1.69	1.80	1.80
Average Recruitment (1977, 2001)	17.46	17.61	17.61	19.73	19.76
Total biomass 2001	104,516	105,704	105,705	123,455	123,672
(CV)	(38%)	(38%)	(38%)	(40%)	(40%)

*Recommended model for ABC determination

The likelihood components, penalties and selected measures of stock status are similar for the 5 model runs. The addition of fishery age compositions in Model 2 does not have much influence on the selected model results. This is most likely due to the agreement between the trends in fishery and survey compositions which both suggest a larger than average year class during the years 1982 - 1985 (Figures 6-2 and 6-9). Removal of the spawner recruit relationship from the estimation of B_0 in Model 3 also does not seem to affect the model results. However, reformulation of survey catchability in Models 4 and 5 does affect model results. In particular, the parameter estimate for *q*, the average recruitment, and the ending biomass all increase. This behavior results from a penalty placed on the deviations of estimated *q* from a prior assumption that the value of *q* is equal to one (see description of priors, Courtney et al. (1999)). In the northern rockfish assessment, the penalty is tuned to an estimate of *q* relative to average survey selectivity while in the template model, the penalty is tuned to an estimate of *q* relative to full survey selectivity. The reformulation of fishery mortality regularity and deviation penalties in Model 5 does not appear to influence model results.

Model 2, last year's northern rockfish assessment model with the addition of fishery age compositions and associated likelihood components, is recommended for this year's assessment. Small changes in estimated survey catchability can have a large influence on model results. Consequently, more exploratory model runs with the new estimate of survey catchability, *q*, should be examined before models 4 or 5 can be recommended for ABC calculations for northern rockfish. Also, the removal of the spawner recruit relationship, Model 3, may not be necessary. A variation of the rockfish template (Model 5), with the addition of a spawner recruit relationship, will be evaluated for implementation in next years assessment.

6.6.2.3 Results for Northern Rockfish

Fits of model 2 to survey age compositions and survey biomass estimates are shown in Figures 6-13 and 6-14. Estimates of the time series of female spawning biomass, total biomass (age 6 and greater), catch/(6+ total biomass), and number of age-two recruits from model 2 are shown in Table 6-16. Estimates of the trend in recent spawning biomass and estimated number of recruits from model 2 are shown in Figures 6-15 and 6-16, respectively. A summary of the current model 2 estimates of age composition, fishery and survey selectivity, maturity at age, and weight at age from model 2 is in Table 6-17.

The number of age-2 recruits in 2002 was estimated as the average recruitment from the 1977 - 1993 year classes. Estimated female spawning biomass from model 2 in 2002 is 40,070 mt, exploitable biomass is 94,354 mt, and age 6+ total biomass is 97,450 mt.

Recruitment since 1988 has been below average, and the current population is dominated by older fish from three strong year classes (1968-1970, 1975-1977, and 1982-1984). The spread in these strong year classes is likely due to ageing error. According to the age structured model, the spawning biomass of these large year classes has already peaked (between 1991 and 1992), and spawning biomass is projected to decrease as these large year classes die off (based upon average recruitment from 1979-1995). Unless another strong year class appears, spawning biomass is projected to fall below $B_{40\%}$ in 2011 and yield is projected to fall below equilibrium yield at $F_{40\%}$ (3,681 mt) by 2007 (Figure 6-15).

The use of an age-structured model has improved our understanding of northern rockfish population dynamics, however there is still considerable uncertainty in the estimates of population abundance. Biomass projections from the age structured model are highly uncertain. The 2001 ending biomass estimated from the age structured model had a coefficient of variation of nearly 40% (based upon the covariance matrix from the AD Model output). This is a minimum estimate of variation that does not take into account the uncertainty of independently estimated parameters such as natural mortality and maturity. For example, estimates of maturity at age are uncertain because they are based on a small sample of fish (n=77) collected in one year. The calculation of $F_{40\%}$ and $B_{40\%}$ depend on estimates of maturity.

The fit to the survey abundance index is poor, and improving the fit changes the resulting biomass estimate. Courtney et al. (1999) tested the model sensitivity to the likelihood weights on the abundance index. Increasing the likelihood weight on the abundance index improved the fit of the abundance index and all the other data except the age data. However, the population representation implied by the age data was chosen as the most reasonable representation of the population structure for this assessment (i.e., the Alternative case from Courtney et al. 1999). The uncertainty inherent in this choice was examined in last years assessment (Heifetz et al. 2000). By increasing the likelihood weight of the survey abundance index from 1(the value used in the current assessment) to 5 (the population representation implied by a stronger fit to survey abundance and the maximum weight from Courtney et al. 1999), the resultant 2000 ending biomass estimate was increased by approximately 50%. This model sensitivity changes in survey biomass weights underscores the uncertainty in the current biomass estimate.

6.6.3 Shortraker and Rougheye Rockfish, and Other Slope Rockfish

As in the past, the average of the exploitable biomasses in the three most recent surveys (1996, 1999, and 2001) is used to determine current exploitable biomass of shortraker and rougheye rockfish and other slope rockfish (Table 6-18). There was no survey of the Eastern Gulf of Alaska in 2001, so the average of the 1993, 1996, and 1999 survey estimates was used in place of a 2001 Eastern Gulf value. These estimates are derived from the Gulf wide biomass estimates listed in Table 6-8, excluding the biomass in the 1-100 m depth stratum. The 1-100 m depth stratum was removed from the estimate because most slope rockfish in this stratum are small juvenile fish younger than the age of recruitment, and thus are not considered exploitable (Clausen and Heifetz 1989). These averages yield the following values of current exploitable biomass: 25,473 mt for shortraker rockfish, 41,356 mt for rougheye rockfish, and 107,962 mt for other slope rockfish.

Development of an age-structured model for rougheye rockfish was initiated this year using the AD Model Builder rockfish template[7]. The rougheye model starts in 1977 and has 40 age bins and 39 length bins. Catch data from Soh (1998), survey biomass estimates and size compositions from 6 triennial trawl survey biomass estimates from 1984-1999, 1 year of trawl survey age composition, 5 years of fishery size composition, and 1 year of fishery age composition were input to the template model. A size-age transition matrix was derived from a lognormal fit of Von Bertalanffy growth curve to data from Malecha and Heifetz (2000). A second survey was added to the model so that 13 years of abundance indices and 3 years of size composition data from the longline survey could be incorporated. There are no available estimates of catch prior to 1977, although they were likely taken in significant numbers during the foreign fisheries in the 1960's and early 1970's. Because the template model assumes the population has been unfished at the start of the model, a lack of old fish in the age composition data for these long lived species results in a strongly dome-shaped fishery and survey selectivity curve. The rougheye model was modified to allow for fishing prior to 1977, giving an alternate explanation for the lack of old fish and much less dome-shaped selectivity curves. Assessing rougheye rockfish with an age-structured model is still in a very preliminary stage

6.7 PROJECTIONS AND HARVEST ALTERNATIVES

6.7.1 Pacific Ocean Perch

6.7.1.1 Harvest Alternatives

Several alternate model configurations were evaluated in section 6.6.1. ABCs from these alternative models ranged 10,860 - 17,770 mt. The base model which had all likelihood emphasis factors set at 1 gave an ABC of 13,190. We recommend that the ABC from this base model be used for the 2002 fishery. The ABC is based on an $F_{40\%}$ harvest rate. While we expect several refinements to the model to be made for next year assessment, this ABC is similar to last year's ABC of 13,510, and the model used new data (i.e., updated catch, 2001 trawl survey estimates, and 2000 fishery age compositions). The corresponding reference values for Pacific ocean perch for alternative models are summarized in the following:

	Model					
	1 * Base	2 Survey biomass emphasis = 5	3 Fishery size emphasis = 0.5	4 Survey q fixed at 2.9	5 Domed fishery selectivity	6 Projection
$B_{40\%}$ (mt)	98,790	122,500	91,820	99,300	100,050	110,120
B_{2002} (mt)	107,070	141,340	88,680	108,190	109,700	96,100
$F_{40\%}$	0.050	0.050	0.050	0.054	0.061	0.078
F_{ABC} (maximum	0.050	0.050	0.048	0.054	0.061	0.070
ABC (mt)	13,190	17,770	10,860	13,230	13,200	14,270

[7]Rockfish Modeling Workshop, NMFS Auke Bay Laboratory, 11305 Glacier Hwy., Juneau, AK. February, 2001.

* Recommended for ABC calculation

Based on model 1, the current spawning biomass in 2002, B_{2002}, is 98,790 mt. $B_{40\%}$ is determined from average recruitment of the 1977-93 year-classes (Figure 6-17). Since B_{2002} is less than $B_{40\%}$, the computation in tier 3a [i.e., $F_{ABC} \leq F_{40\%}$] is used to determine the maximum value of F_{ABC} resulting in an ABC ≤ 13,190 mt. We recommend that the ABC for Pacific ocean perch for 2002 fishery in the Gulf of Alaska be set at 13,190 mt.

6.7.1.2 Projections

A standard set of projections is required for each stock managed under Tiers 1, 2, or 3. This set of projections that encompasses seven harvest scenarios is designed to satisfy the requirements of Amendment 56, the National Environmental Protection Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA). Figure 6-18 shows the recent trend and projection of yield and spawning biomass based on average recruitment and a $F_{40\%}$ harvest rate.

For each scenario, the projections begin with the vector of 2001 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2002 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 2001. In each subsequent year, the fishing mortality rate is prescribed on the basis of the spawning biomass in that year and the respective harvest scenario. In each year, recruitment is drawn from an inverse Gaussian distribution whose parameters consist of maximum likelihood estimates determined from recruitments estimated in the assessment. Spawning biomass is computed in each year based on the time of peak spawning and the maturity and weight schedules described in the assessment. Total catch is assumed to equal the catch associated with the respective harvest scenario in all years. This projection scheme is run 1000 times to obtain distributions of possible future stock sizes, fishing mortality rates, and catches.

Five of the seven standard scenarios will be used in an Environmental Assessment prepared in conjunction with the final SAFE. These five scenarios, which are designed to provide a range of harvest alternatives that are likely to bracket the final TAC for 2002, are as follow ("*max* F_{ABC}" refers to the maximum permissible value of F_{ABC} under Amendment 56):

Scenario 1: In all future years, F is set equal to *max* F_{ABC}. (Rationale: Historically, TAC has been constrained by ABC, so this scenario provides a likely upper limit on future TACs.)

Scenario 2: In all future years, F is set equal to a constant fraction of *max* F_{ABC}, where this fraction is equal to the ratio of the F_{ABC} value for 2002 recommended in the assessment to the *max* F_{ABC} for 2002. (Rationale: When F_{ABC} is set at a value below *max* F_{ABC}, it is often set at the value recommended in the stock assessment.)

Scenario 3: In all future years, F is set equal to 50% of max F_{ABC}. (Rationale: This scenario provides a likely lower bound on F_{ABC} that still allows future harvest rates to be adjusted downward when stocks fall below reference levels.)

Scenario 4: In all future years, F is set equal to the 1995-1999 average F. (Rationale: For some stocks, TAC can be well below ABC, and recent average F may provide a better indicator of F_{TAC} than F_{ABC}.)

Scenario 5: In all future years, F is set equal to zero. (Rationale: In extreme cases, TAC may be set at a level close to zero.)

Two other scenarios are needed to satisfy the MSFCMA's requirement to determine whether a stock is currently in an overfished condition or is approaching an overfished condition. These two scenarios are as follows (for Tier 3 stocks, the MSY level is defined as $B_{35\%}$):

Scenario 6: In all future years, F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is overfished. If the stock is expected to be above ½ of its MSY level in 2001 and above its MSY level in 2011 under this scenario, then the stock is not overfished.)

Scenario 7: In 2002 and 2003, F is set equal to *max* F_{ABC}, and in all subsequent years, F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is approaching an overfished condition. If the stock is expected to be above its MSY level in 2014, under this scenario, then the stock is not approaching an overfished condition)

A summary of the results of these scenarios for Pacific ocean perch is in Table 6-19. For Pacific ocean perch the stock is not overfished nor is it approaching an overfished condition.

6.7.1.3 Apportionment of ABC

Prior to the 1996 fishery, the apportionment of ABC among areas was determined from distribution of biomass based on the average proportion of exploitable biomass by area in the most recent three triennial trawl surveys. For the 1996 fishery, an alternative method of apportionment was recommended by the Plan Team and accepted by the Council. Recognizing the uncertainty in estimation of biomass yet wanting to adapt to current information, the Plan Team chose to employ a method of weighting prior surveys based on the relative proportion of variability attributed to survey error. Assuming that survey error contributes 2/3 of the total variability in predicting the distribution of biomass (a reasonable assumption), the weight of a prior survey should be 2/3 the weight of the preceding survey. This resulted weights of 4:6:9 for the 1993, 96, and 99 surveys, respectively and apportionments of 9.5% for the Western area, 71.1 % for the Central area, and 19.4% for the Eastern area. Dropping the 1993 survey and adding the 2001 survey results in apportionments of 19.8% for the Western area, 62.3 % for the Central area, and 17.9% for the Eastern area (Table 6-20). This results in recommended ABC's of 2,610 mt for the Western area, 8,220 mt for the Central area, and 2,360 mt for the Eastern area.

6.7.2 Northern Rockfish

Except for the addition of two years of fishery age compositions and the 2001 survey biomass estimate, the model used to recommend northern rockfish ABC this year is the same as the northern rockfish age-structured model from last years SAFE. A detailed report describing the northern rockfish model configuration was presented in an earlier SAFE report (Courtney et al. 1999). Based on this year's recommended assessment model (Model 2), the projected current spawning biomass in 2002 B_{2002} is 40,070 mt. $B_{40\%}$, determined from average recruitment of the 1977-93 year-classes is 23,330 mt. B_{2002} is greater than $B_{40\%}$. Consequently, the computation in tier 3a [i.e., $F_{ABC} \leq F_{40\%}$] is used to determine the maximum value of F_{ABC}. As in last year's assessment, we recommend that $F_{40\%}$ be used as the basis for ABC calculations. We recommend that the ABC for northern rockfish for the 2002 fishery in the Gulf of Alaska be set 4,980 mt (Model 2).

The corresponding stock assessment reference values for northern rockfish are summarized in the following:

	Model				
	1	2*	3	4	5
$B_{40\%}$ (mt)	23,110	23,330	23,330	26,210	26,250

			Model		
B_{2002} (mt)	39,530	40,070	40,070	47,100	47,530
$F_{40\%}$	0.056	0.056	0.056	0.056	0.056
F_{ABC} in 2002 (maximum allowable)	0.056	0.056	0.056	0.056	0.056
ABC in 2002 (mt; maximum allowable)	4,910	4,980	4,980	5,850	5,860

* recommended model for ABC determination

The model recommended for this year's assessment (Model 2) differs from last year's assessment model (Model 1) only by the addition of two years of fishery age compositions, and the associated likelihood components. Projected spawning biomass (B_{2002}), equilibrium spawning biomass ($B_{40\%}$), and ABC for 2002 from the model recommended for this year (Model 2) are similar to those from the model used in last years assessment (Model 1). Estimates of $F_{40\%}$ are identical for all models. Models 3, 4 an 5 are variations of a rockfish workshop template described above.

Given the uncertainty in the biomass estimates obtained from all 5 versions of the age structured model, the catch history, and the uncertain life history parameters, a model which results in a more conservative ABC, which is similar to that obtained last year, appears to be reasonable. The declining stock trend and the weakness of recent recruitment estimates identified by the age structured model indicates that caution is warranted for management of this stock.

The standard set of projections described for Pacific ocean perch were run for northern rockfish (Model 2). A summary of the results of these scenarios is in Table 6-21. For northern rockfish, projected B_{2002} (40,070 mt) is greater than $B_{35\%}$ (20,410 mt) and by the definitions above, the stock is not overfished. In addition, B_{2004} (35,020 mt) is greater than $B_{35\%}$ and by the definitions above the stock is not approaching an overfished condition.

Using the same method of apportionment as used for Pacific ocean perch results in ABC's of 805 mt (16.16%) in the Western area, 4,172 mt (83.76%) in the Central area, and 4 mt (0.08%) in the Eastern area (Table 6-20). For management purposes, the small ABC of northern rockfish in the Eastern area is combined with other slope rockfish.

6.7.3 Shortraker and Rougheye Rockfish

In the past, the recommended ABC for shortraker and rougheye rockfish was based on an exploitation rate set equal to natural mortality. Based on recommendations of the Scientific and Statistical Committee (SSC), estimates of M were obtained from Table 6-12 which lists estimates of total mortality Z based on catch curve analyses. The SSC estimated an M of 0.025 for rougheye rockfish based on the mid-point of the range of Z for British Columbia stocks and because there was no estimate of M or Z for shortraker rockfish, the ratio of maximum age of rougheye to shortraker (140/120) multiplied by 0.025 was used to estimate an M of 0.03.

Applying the definitions for ABC and OFL based on Amendment 44 on the Gulf of Alaska FMP places shortraker rockfish in tier 5 where $F_{ABC} \leq 0.75M$. Thus, the recommended F_{ABC} for shortraker rockfish is 0.023 (ie., 0.75 X 0.03). Applying tier 4 to rougheye rockfish (ie., $F_{ABC} \leq F_{40\%}$) results an F_{ABC}=M= 0.025 which is less than $F_{40\%}$=0.032. Applying these F_{ABC}'s to the estimates of exploitable biomass based of 25,473 mt for shortraker rockfish and 41,356 mt for rougheye rockfish results in ABC's of 586 mt for shortraker rockfish and 1,034 mt for rougheye rockfish and a recommended ABC for the subgroup of 1,620 mt.

For species such as shortraker and rougheye rockfish that are not assessed with a age/length- structured model multi-year projections as done in Table 6-19 for Pacific ocean perch are not possible but yields for just the year 2002 can be computed (Table 6-22).

The same method of apportionment as used for Pacific ocean perch is used to apportion the shortraker and rougheye ABC among areas (Table 6-20). This results in ABC's of 220 mt for the Western area, 840 mt for the Central area, and 560 mt for the Eastern area.

6.7.4 Other Slope Rockfish

In the past, the recommended ABC for other slope rockfish was based on a harvest rate set equal to natural mortality M. Estimates of M obtained from Table 6-12 are 0.05 sharpchin rockfish and 0.10 for redstripe rockfish. The estimate of M of 0.04 for silvergrey rockfish is based on the midpoint of the range of Z (0.01-0.07) for British Columbia stocks. For harlequin and redbanded rockfish and minor species, an F=M of 0.06 is based on the average M for northern, sharpchin, redstripe, and silvergrey rockfish. Applying the new definitions for ABC and OFL based on Amendment 44 in the Gulf of Alaska FMP places sharpchin rockfish in tier 4 where $F_{ABC} \leq F_{40\%}$, and the other species of other slope rockfish in tier 5 where $F_{ABC} \leq 0.75M$. Applying $F_{ABC} = M = 0.05$ to the exploitable biomass of sharpchin rockfish and $F_{ABC} = 0.75M$ to the exploitable biomass of the other species results in a recommended combined ABC for other slope of 5,038 mt. Distributing this ABC based on the same method used for Pacific ocean perch results in ABC's of 87 mt in the Western area, 552 mt in the Central area, and 4,399 mt in the Eastern area (Table 6-20).

For species such as other slope rockfish that are not assessed with a age/length- structured model multi-year projections as done in Table 6-19 for Pacific ocean perch are not possible but yields for just the year 2002 can be computed (Table 6-22).

6.7.5 Overfishing Definition

6.7.5.1 Pacific ocean perch and northern rockfish

Based on the definitions for overfishing in Amendment 44 in tier 3a (i.e., $F_{OFL} = F_{35\%}$=0.059), overfishing is set equal to 15,670 mt for Pacific ocean perch. The overfishing level is apportioned by area for Pacific ocean perch. Using the apportionment in Section 6.7.1, results in overfishing levels by area of 3,110 mt in the Western area, 9,760 mt in the Central area, and 2,800 mt in the Eastern area.

Based on the definitions for overfishing in Amendment 44 in tier 3a [i.e., $F_{OFL} = F_{35\%} = 0.067$], overfishing is set equal to 5,900 mt for northern rockfish.

6.7.5.2 Rougheye, shortraker and other slope rockfish

Based on Amendment 44 in the Gulf of Alaska FMP overfishing is defined to occur at the harvest rate set equal to $F_{35\%}$ (in terms of exploitable biomass per recruit) of 0.038 for rougheye rockfish. The F=M rate of 0.03 is used to define the overfishing level for shortraker rockfish because data are not available to determine $F_{30\%}$ for shortraker rockfish. These harvest rates are applied to estimates of current exploitable biomass to yield an overfishing catch limit of 2,340 mt for the shortraker/rougheye subgroup.

Overfishing is defined to occur at the $F_{35\%}$ (in terms of exploitable biomass per recruit) values of 0.064 for sharpchin rockfish. For the other species of other slope rockfish, overfishing is defined to occur at the F=M rate. Applying these F's, results in an overfishing catch limit of 6,390 mt for the other slope rockfish subgroup.

6.7.8 Summary

A summary of biomass levels, exploitation rates and recommended ABCs and OFLs for slope rockfish is in Table 6-23.

6.7.9 Rockfish work plan

Stock assessment of slope rockfish is hampered by limited information and considerable uncertainty as to current stock abundance and long-term productivity. The adequacy of current trawl survey methodology to assess rockfish biomass is questionable. These concerns have prompted the Alaska Fisheries Science Center to develop a comprehensive working plan to improve stock assessments for rockfish. The main focus of this plan is to develop and prioritized research proposals for improving rockfish assessment and management. Included in this plan are proposals for alternative survey designs that use the skill and fish-catching ability of a commercial fishing operation and experimental management schemes designed to provide a better understanding of stock dynamics. In cooperation with the University of Alaska Fairbanks, NMFS scientists are currently evaluating adaptive sampling as a possible method of improving trawl survey biomass estimates (Clausen et al., 1999; Quinn et al. 2000).

A simple age-structured model template (with allowance for size composition data) in AD Model Builder has been developed for application to rockfish populations. The development of this template will facilitate the implementation of age-structured models for other rockfish species by reducing model development time while still allowing features to be added to account for additional data types and special fishery characteristics. Next year, the base model template will be evaluated for sensitivity to assumptions and data requirements.

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Table 6-1.--Species comprising the slope rockfish assemblage in the Gulf of Alaska.

Common name	Scientific name	Management subgroup
Pacific ocean perch	*Sebastes alutus*	Pacific ocean perch
Shortraker rockfish	*S. borealis*	Shortraker/rougheye
Rougheye rockfish	*S. aleutianus*	Shortraker/rougheye
Northern rockfish	*S. polyspinis*	Northern rockfish
Sharpchin rockfish	*S. zacentrus*	Other slope rockfish
Redstripe rockfish	*S. proriger*	Other slope rockfish
Harlequin rockfish	*S. variegatus*	Other slope rockfish
Silvergrey rockfish	*S. brevispinis*	Other slope rockfish
Redbanded rockfish	*S. babcocki*	Other slope rockfish
Yellowmouth rockfish	*S. reedi*	Other slope rockfish
Bocaccio	*S.paucispinis*	Other slope rockfish
Greenstriped rockfish	*S. elongatus*	Other slope rockfish
Darkblotched rockfish	*S. crameri*	Other slope rockfish
Pygmy rockfish	*S. wilsoni*	Other slope rockfish
Splitnose rockfish	*S. diploproa*	Other slope rockfish
Aurora rockfish	*S. aurora*	Other slope rockfish
Blackgill rockfish	*S. melanostomus*	Other slope rockfish
Chilipepper	*S. goodei*	Other slope rockfish
Shortbelly rockfish	*S. jordani*	Other slope rockfish
Stripetail rockfish	*S. saxicola*	Other slope rockfish
Vermilion rockfish	*S. miniatus*	Other slope rockfish

Table 6-2a.–Commercial catch[a] (mt) of fish in the slope rockfish assemblage in the Gulf of Alaska, with Gulfwide values of acceptable biological catch (ABC) and fishing quotas[b] (mt), 1977-2001. Catches in 2001 updated through October 6, 2001.

Year	Fishery category	Regulatory area: Western	Central	Eastern	Gulfwide Total	Gulfwide Management value: ABC	Quota
1977	Foreign	6,282	6,166	10,993	23,441		
	U.S.	0	0	12	12		
	JV	-	-	-	-		
	Total	6,282	6,166	11,005	23,453	50,000	30,000
1978	Foreign	3,643	2,024	2,504	8,171		
	U.S.	0	0	5	5		
	JV	-	-	-	-		
	Total	3,643	2,024	2,509	8,176	50,000	25,000
1979	Foreign	944	2,371	6,434	9,749		
	U.S.	0	99	6	105		
	JV	1	31	35	67		
	Total	945	2,501	6,475	9,921	50,000	25,000
1980	Foreign	841	3,990	7,616	12,447		
	U.S.	0	2	2	4		
	JV	0	20	0	20		
	Total	841	4,012	7,618	12,471	50,000	25,000
1981	Foreign	1,233	4,268	6,675	12,176		
	U.S.	0	7	0	7		
	JV	1	0	0	1		
	Total	1,234	4,275	6,675	12,184	50,000	25,000
1982	Foreign	1,746	6,223	17	7,986		
	U.S.	0	2	0	2		
	JV	0	3	0	3		
	Total	1,746	6,228	17	7,991	50,000	11,475
1983	Foreign	671	4,726	18	5,415		
	U.S.	7	8	0	15		
	JV	1,934	41	0	1,975		
	Total	2,612	4,775	18	7,405	50,000	11,475
1984	Foreign	214	2,385	0	2,599		
	U.S.	116	0	3	119		
	JV	1,441	293	0	1,734		
	Total	1,771	2,678	3	4,452	50,000	11,475
1985	Foreign	6	2	0	8		
	U.S.	631	13	181	825		
	JV	211	43	0	254		
	Total	848	58	181	1,087	11,474	6,083
1986	Foreign	Tr	Tr	0	Tr		
	U.S.	642	394	1,908	2,944		
	JV	35	2	0	37		
	Total	677	396	1,908	2,981	10,500	3,702
1987	Foreign	0	0	0	0		
	U.S.	1,347	1,434	2,088	4,869		
	JV	108	4	0	112		
	Total	1,455	1,438	2,088	4,981	10,500	5,000
1988	Foreign	0	0	0	0		
	U.S.	2,586	6,467	4,718	13,771		
	JV	4	5	0	8		
	Total	2,590	6,471	4,718	13,779	16,800	16,800
1989	U.S.	4,339	8,315	6,348	19,002	20,000	20,000
1990	U.S.	5,203	9,973	5,938	21,114	17,700	17,700

Table 6-2.--(Continued)

Year	Management subgroup	Regulatory area: Western	Central	Eastern	Gulfwide Total	Gulfwide Management value: ABC	Quota
1991	POP	1,589	2,956	2,087	6,631	5,800	5,800
	SR/RE	123	408	171	702	2,000	2,000
	Other slope	634	4,011	162	4,806	10,100	10,100
1992	POP	1,266	2,658	2,234	6,159	5,730	5,200
	SR/RE	115	1,367	683	2,165	1,960	1,960
	Other slope	1,068	7,495	875	9,438	14,060	14,060

1993	POP	477	1,140	443	2,060	3,378	2,560
	SR/RE	85	1,197	650	1,932	1,960	1,764
	Northern	902	3,778	145	4,825	5,760	5,760
	Other slope	342	2,423	2,658	5,423	8,300	5,383
1994	POP	165	920	768	1,853	3,030	2,550
	SR/RE	114	996	722	1,832	1,960	1,960
	Northern	1,394	4,519	55	5,968	5,760	5,760
	Other slope	101	715	797	1,613	8,300	2,235
1995	POP	1,422	2,598	1,722	5,742	6,530	5,630
	SR/RE	216	1,222	812	2,250	1,910	1,910
	Northern	113	5,476	45	5,634	5,270	5,270
	Other slope	31	883	483	1,397	7,110	2,235
1996	POP	987	5,145	2,246	8,378	8,060	6,959
	SR/RE	127	941	593	1,661	1,910	1,910
	Northern	173	3,146	24	3,343	5,270	5,270
	Other slope	19	618	244	881	7,110	2,020
1997	POP	1,832	6,720	979	9,531	12,990	9,190
	SR/RE	137	931	541	1,609	1,590	1,590
	Northern	62	2,870	15	2,947	5,000	5,000
	Other slope	68	941	208	1,217	5,260	2,170
1998	POP	850	7,501	610	8,961	12,820	10,776
	SR/RE	129	870	735	1,734	1,590	1,590
	Northern	67	2,974	10	3,051	5,000	5,000
	Other slope	46	701	114	861	5,260	2,170
1999	POP	1,935	7,910	627	10,472	13,120	12,590
	SR/RE	194	580	537	1,311	1,590	1,590
	Northern	574	4,825	c	5,399	4,990	4,990
	Other slope	39	614	135	788	5,270	5,270
2000	POP	1,160	8,379	618	10,157	13,020	13,020
	SR/RE	137	887	721	1,745	1,730	1,730
	Northern	747	2,578	c	3,325	5,120	5,120
	Other slope	49	363	165	577	4,900	4,900
2001	POP	924	9,424	624	10,972	13,510	13,510
	SR/RE	116	984	801	1,901	1,730	1,730
	Northern	523	2,541	c	3,064	4,880	4,880
	Other slope	25	342	211	578	4,900	4,900

Note: There were no foreign or joint venture catches after 1988. Catches prior to 1989 are landed catches only. Catches in 1989 and 1990 also include fish reported in weekly production reports as discarded by processors. Catches in 1991-2001 also include discarded fish, as determined through a "blend" of weekly production reports and information from the domestic observer program.

Definitions of terms: JV = Joint venture; Tr = Trace catches; POP = Pacific ocean perch management subgroup; SR/RE = shortraker/rougheye management subgroup; Other slope = other slope rockfish management subgroup (in 1991-92 consisted of all species in the slope rockfish assemblage except for Pacific ocean perch and shortraker and rougheye rockfish; in 1993-2001 consisted of all species in the slope rockfish assemblage except for Pacific ocean perch and shortraker, rougheye, and northern rockfish); Northern = northern rockfish management subgroup.

[a]Catch defined as follows: 1977, all *Sebastes* rockfish for Japanese catch, and Pacific ocean perch for catches of other nations; 1978, Pacific ocean perch only; 1979-87, the 5 species comprising the Pacific ocean perch complex; 1988-90, the 18 species comprising the slope rockfish assemblage; 1991-93, the 20 species comprising the slope rockfish assemblage; 1994-2001 the 21 species comprising the slope rockfish assemblage.

[b]Quota defined as follows: 1977-86, optimum yield; 1987, target quota; 1988-2001 total allowable catch.

[c]Starting in 1999 in the Eastern area, northern rockfish is combined with other slope rockfish.

Sources: Catch: 1977-84, Carlson et al. (1986); 1985-88, Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, 305 State Office Building, 1400 S.W. 5th Avenue, Portland, OR 97201; 1989-2001, National Marine Fisheries Service, Alaska Region, P.O. Box 21668, Juneau, AK 99802. ABC and Quota: 1977-1986 Karinen and Wing (1987); 1987-2000, Heifetz et al. (2000); 2001, North Pacific Fishery Management Council News and Notes, Dec. 2000. 605 W. 4th Ave., Suite 306, Anchorage, Alaska 99501-2252.

Table 6-2b.–Catch (mt) of slope rockfish taken during research cruises in the Gulf of Alaska, 1977-2001. (Does not include catches in longline surveys before 1995; tr=trace)

Year	Pacific ocean perch	Shortraker/ rougheye	Northern rockfish	Other slope rockfish
1977	13.0	0.7	tr	0.8
1978	5.7	2.8	0.5	9.5
1979	12.2	1.9	1.0	0.4
1980	12.6	1.9	0.5	0.4
1981	57.1	12.5	8.4	16.3
1982	15.2	5.4	6.4	2.9
1983	2.4	3.2	1.7	0.1
1984	76.5	23.7	11.3	3.4
1985	35.2	10.5	10.8	1.7
1986	14.4	2.6	0.7	0.0
1987	68.8	28.1	40.6	19.8
1988	0.3	0.0	0.0	0.7
1989	1.0	0.6	0.2	0.1
1990	25.5	7.6	19.2	11.8
1991	0.1	tr	0.0	tr
1992	0.0	0.1	0.0	0.0
1993	59.2	12.8	20.8	11.3
1994	tr	0.1	0.0	0.0
1995	tr	tr	0.0	0.0
1996	81.2	23.1	12.5	16.9
1997	tr	26.6	0.0	0.0
1998	305.0	82.1	2.5	2.4
1999	330.2	145.4	13.2	51.6
2000	0.0	19.8	0.0	0.0
2001	42.5	16.9	23.4	0.7

Table 6-3a.--Species composition (percent by weight) of the “other slope rockfish” management subgroup in the Gulf of Alaska commercial catch, 1992-2000, based on vessels that had observer coverage. (tr=trace; Redbanded rockfish is not included in the 1992 and 1993 data.)

	Regulatory area			
Species	Western	Central	Eastern	Gulf of Alaska
		1992		
Northern rockfish	92.9	88.7	14.8	82.3
Sharpchin rockfish	0.4	2.3	29.5	4.6
Redstripe rockfish	0.0	1.0	21.3	2.8
Harlequin rockfish	6.6	7.5	12.9	7.9
Silvergrey rockfish	tr	0.1	14.0	1.4
Yellowmouth rockfish	0.1	0.5	7.2	1.1
Other species	tr	tr	0.2	tr
		1993		
Northern rockfish	(removed from subgroup in 1993)			
Sharpchin rockfish	1.8	23.9	28.6	24.8
Redstripe rockfish	5.6	25.2	22.3	22.5
Harlequin rockfish	92.3	48.0	14.5	34.4
Silvergrey rockfish	tr	2.3	15.9	8.2
Yellowmouth rockfish	tr	0.7	18.1	9.2
Other species	0.2	tr	0.6	0.3
		1994		
Sharpchin rockfish	2.1	14.8	27.9	20.5
Redstripe rockfish	0.0	3.9	22.5	12.9
Harlequin rockfish	97.3	77.7	17.0	49.0
Silvergrey rockfish	0.0	0.6	26.9	13.6
Yellowmouth rockfish	0.1	0.9	4.2	2.5
Redbanded rockfish	0.5	2.0	1.0	1.4
Other species	tr	tr	0.5	0.2
		1995		
Sharpchin rockfish	6.1	26.0	23.0	24.5
Redstripe rockfish	1.5	6.4	29.2	14.1
Harlequin rockfish	73.1	63.6	17.2	47.8
Silvergrey rockfish	0.0	0.2	25.0	8.8
Yellowmouth rockfish	6.6	0.1	2.5	1.1
Redbanded rockfish	12.6	1.2	1.6	1.6
Other species	1.6	2.5	1.5	2.2

Table 6-3a.--(Continued).

Species	Regulatory area Western	Central	Eastern	Gulf of Alaska
		1996		
Sharpchin rockfish	18.3	29.0	48.1	31.6
Redstripe rockfish	6.8	14.7	19.2	15.2
Harlequin rockfish	67.6	52.0	7.1	45.7
Silvergrey rockfish	0.0	0.6	2.8	0.9
Yellowmouth rockfish	0.0	tr	4.8	0.7
Redbanded rockfish	6.6	2.4	8.2	3.4
Other species	0.7	1.3	9.9	2.6
		1997		
Sharpchin rockfish	36.2	26.3	22.6	26.0
Redstripe rockfish	37.0	26.3	8.2	23.9
Harlequin rockfish	21.8	44.9	17.7	40.4
Silvergrey rockfish	0.0	1.5	11.2	2.8
Yellowmouth rockfish	0.5	tr	35.5	5.2
Redbanded rockfish	3.3	0.8	3.5	1.2
Other species	1.1	0.3	1.2	0.5
		1998		
Sharpchin rockfish	23.6	41.7	tr	37.0
Redstripe rockfish	0.5	1.2	51.4	5.9
Harlequin rockfish	72.5	52.1	35.8	51.5
Silvergrey rockfish	tr	0.6	3.7	0.9
Yellowmouth rockfish	0.0	tr	0.4	0.1
Redbanded rockfish	3.4	2.2	3.0	2.3
Other species	0.0	2.2	5.7	2.4
		1999		
Sharpchin rockfish	6.0	25.9	18.7	21.5
Redstripe rockfish	23.1	11.1	14.4	13.6
Harlequin rockfish	45.0	58.7	53.2	55.6
Silvergrey rockfish	0.0	0.7	10.1	2.4
Yellowmouth rockfish	0.0	0.1	1.0	0.3
Redbanded rockfish	1.5	3.2	2.1	2.7
Other species	24.3	0.2	0.5	4.0

Table 6-3a.--(Continued).

Species	Regulatory area: Western	Central	Eastern	Gulf of Alaska
		2000		
Sharpchin rockfish	0.0	56.0	24.6	47.4
Redstripe rockfish	0.8	6.5	33.4	8.9
Harlequin rockfish	91.2	26.3	25.7	32.2
Silvergrey rockfish	0.0	2.4	12.2	3.3
Yellowmouth rockfish	5.7	2.0	0.4	2.2
Redbanded rockfish	2.3	4.6	3.4	4.3
Other species	0.0	2.2	0.2	1.7

Table 6-3b.–Species composition (percent by weight of the “shortraker/rougheye management subgroup in the Gulf of Alaska commercial, 1992-2000, based on vessels that had observer coverage.

Species	Regulatory area: Western	Central	Eastern	Gulf of Alaska
		1992		
Shortraker rockfish	45.8	49.1	70.1	55.5
Rougheye rockfish	54.2	50.9	29.9	44.5
		1993		
Shortraker rockfish	73.3	62.7	82.8	69.9
Rougheye rockfish	26.7	37.3	17.2	30.1
		1994		
Shortraker rockfish	58.3	62.6	85.4	71.3
Rougheye rockfish	41.7	37.4	14.6	28.7
		1995		
Shortraker rockfish	44.3	65.8	81.1	69.3
Rougheye rockfish	55.7	34.2	18.9	30.7
		1996		
Shortraker rockfish	57.9	55.7	80.0	62.8
Rougheye rockfish	42.1	44.3	20.0	37.2
		1997		
Shortraker rockfish	82.5	52.8	78.6	63.6
Rougheye rockfish	17.5	47.2	21.4	36.4
		1998		
Shortraker rockfish	61.4	30.8	94.3	51.0
Rougheye rockfish	38.6	69.2	5.7	49.0
		1999		
Shortraker rockfish	79.7	62.6	85.1	72.5
Rougheye rockfish	20.3	37.4	14.9	27.5
		2000		
Shortraker rockfish	46.4	66.6	85.2	68.7
Rougheye rockfish	53.6	33.4	14.8	31.3

Table 6-4. Fishery length frequency data for Pacific ocean perch in the Gulf of Alaska.

Length class (cm)	Year											
	1977	1978	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
<15	0	0	104	11	23	0	0	0	1	8	0	0
15	0	0	58	3	8	0	0	0	0	3	0	0
16	2	0	33	16	20	0	0	0	0	23	0	0
17	1	0	21	31	29	0	0	0	0	35	0	0
18	2	0	54	17	24	0	0	0	0	69	0	0
19	3	0	15	56	33	0	0	0	0	25	1	0
20	9	0	41	118	26	0	0	1	0	25	3	1
21	14	0	64	145	50	0	0	0	2	27	7	0
22	20	0	66	149	62	0	0	1	1	30	4	0
23	56	1	148	233	65	0	1	9	4	37	6	4
24	100	2	214	253	82	0	0	21	6	34	19	7
25	134	4	239	252	106	0	0	36	18	52	25	7
26	198	12	378	339	116	0	0	65	27	80	36	14
27	314	33	473	266	134	0	1	50	38	120	29	12
28	484	67	599	204	134	0	2	46	42	126	35	18
29	630	130	935	217	193	1	4	67	68	164	49	29
30	890	263	1,455	199	283	3	2	68	103	227	53	21
31	1,306	415	2,123	297	449	5	3	132	196	259	97	22
32	1,710	484	3,161	470	705	14	11	255	326	345	138	53
33	2,026	429	4,459	663	1,288	17	40	535	728	641	277	119
34	2,131	286	5,389	1,074	1,825	25	94	844	1,361	1,074	769	252
35-38	7,492	173	21,463	5,507	5,889	60	610	3,389	6,480	7,861	8,761	2,054
>38	1,866	0	10,181	3,387	1,519	5	128	1,043	1,462	3,312	3,210	720

Table 6 - 5. Fishery length frequency data for northern rockfish in the Gulf of Alaska.

Length class (cm)	Year									
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
15-24	8	4	0	2	1	42	1	8	18	7
25	8	9	1	4	0	47	2	34	2	5
26	4	21	3	10	1	74	0	72	6	13
27	18	33	4	11	5	97	3	106	5	15
28	36	64	17	23	14	88	5	109	9	7
29	73	110	38	57	29	110	9	109	14	7
30	80	288	78	112	57	134	30	90	24	15
31	96	529	173	248	135	164	26	57	23	20
32	151	967	385	484	246	222	66	62	60	37
33	207	1,733	670	830	568	453	162	108	109	80
34	333	2,550	1,247	1,132	946	864	351	206	211	122
35	547	2,741	1,912	1,631	1,421	1,364	706	426	475	173
36	800	2,008	2,162	1,754	1,623	1,652	1,026	618	891	361
37	738	1,222	2,128	1,359	1,391	1,714	1,041	681	1,160	534
38	550	610	1,824	1,073	811	1,371	785	616	1,069	685
39	360	288	1,286	729	431	863	544	371	771	567
40	168	131	810	514	203	400	346	207	445	449
41	79	87	443	359	96	211	191	95	207	271
42	37	27	165	189	55	162	95	43	82	134
43	18	47	59	49	38	117	48	19	46	77
44	8	32	55	9	28	97	22	9	19	31
45-50	8	86	64	3	39	222	68	2	6	57
Total	4,327	13,587	13,524	10,582	8,138	10,468	5,527	4,048	5,652	3,667

Table 6-6.--Relative population number (RPN) and relative population weight (RPW) for rougheye and shortraker rockfish in the Gulf of Alaska domestic longline survey. Data are for the upper continental slope only, 201-1,000 m. depth (gullies are not included).

	Year													
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Rougheye RPN:														
Shumagin	2,663	5,355	4,832	3,670	7,425	6,774	3,923	9,487	5,686	7,027	5,983	6,303	10,748	8,237
Chirikof	937	1,922	1,034	1,091	970	1,507	743	1,476	1,009	1,244	1,163	1,670	2,021	4,489
Kodiak	2,523	3,198	5,522	5,005	4,196	4,028	1,951	4,526	4,494	4,290	5,065	4,987	7,852	4,068
Yakutat	2,921	4,092	3,557	4,934	4,097	5,100	2,973	4,169	4,616	4,945	3,753	5,512	5,294	4,388
Southeast	4,453	9,322	5,390	11,370	4,996	6,027	10,184	7,555	10,224	16,922	9,632	11,132	13,461	7,441
Total	13,497	23,889	20,335	26,070	21,684	23,436	19,773	27,214	26,029	34,428	25,596	29,604	39,375	28,624
Rougheye RPW:														
Shumagin	3,177	6,609	5,352	3,914	7,681	6,303	3,970	11,624	5,519	8,095	6,872	6,273	10,787	8,245
Chirikof	1,185	2,414	1,281	1,287	1,279	1,743	914	1,787	1,375	1,619	1,527	2,053	2,416	5,616
Kodiak	2,786	3,751	6,409	5,338	4,504	4,091	1,994	4,728	4,621	4,224	5,598	4,900	7,705	4,407
Yakutat	3,815	5,116	4,398	6,480	4,513	5,025	3,313	4,394	5,069	5,495	4,271	5,629	6,051	4,105
Southeast	5,975	13,069	7,412	15,555	6,871	8,807	15,593	10,311	14,001	23,754	12,728	14,372	19,450	10,765
Total	16,938	30,959	24,852	32,574	24,849	25,970	25,784	32,843	30,585	43,187	30,996	33,227	46,408	33,138
Shortraker RPN:														
Shumagin	4,492	3,272	3,015	3,074	1,660	1,523	2,549	5,765	4,098	2,888	4,630	5,011	9,481	5,150
Chirikof	1,290	858	773	776	572	229	613	531	646	918	973	823	1,298	1,031
Kodiak	2,332	2,691	3,476	2,412	1,374	1,067	1,040	1,325	2,231	2,200	2,498	3,078	2,904	3,703
Yakutat	5,830	6,492	9,281	10,575	9,130	7,121	5,222	7,992	8,409	12,408	15,295	13,394	13,995	14,177
Southeast	1,420	1,972	1,403	2,247	1,479	2,199	1,862	2,427	1,967	2,459	3,258	3,167	4,025	2,646
Total	15,364	15,285	17,948	19,085	14,214	12,139	11,286	18,039	17,352	20,873	26,654	25,473	31,703	26,706
Shortraker RPW:														
Shumagin	4,869	4,301	5,004	5,953	2,078	2,192	3,956	7,940	5,946	4,468	6,716	6,954	15,050	7,314
Chirikof	2,591	1,449	1,216	1,384	914	293	1,174	812	1,007	1,471	1,422	1,165	1,607	1,682
Kodiak	5,043	5,833	6,787	4,874	2,802	1,912	2,649	2,554	4,657	4,273	5,201	5,562	5,553	7,413
Yakutat	13,320	13,335	19,093	20,585	17,033	14,411	11,046	15,248	17,352	26,830	30,685	26,500	28,754	28,382
Southeast	2,474	3,384	2,214	3,546	2,053	4,124	3,102	4,034	3,377	3,970	5,818	4,569	7,099	4,574
Total	28,297	28,302	34,313	36,343	24,880	22,932	21,927	30,588	32,338	41,013	49,842	44,750	58,063	49,365

Table 6-7.--Estimated biomass (mt), by area, for slope rockfish in the 2001 biennial trawl survey of the Gulf of Alaska. Gulfwide 95% confidence bounds (mt) are also listed. Note: data in this table are for total biomass in the survey. For exploitable biomass, see Table 6-18.

Species	Shumagin	Chirikof	Kodiak	Yakutat*	South-eastern*	Gulfwide Total*	95% Gulfwide Confidence Bounds Lower*	Upper*
	Statistical areas							
Pacific ocean perch	285,180	39,819	387,078	44,392	102,514	858,982	377,720	1,340,244
Shortraker rockfish	4,313	1,589	11,528	7,350	3,149	27,929	18,832	37,026
Rougheye rockfish	6,947	3,592	21,209	7,256	4,780	43,784	28,490	59,078
Shortraker/rougheye	11,260	5,182	32,737	14,606	7,929	71,713	53,918	89,508
Northern rockfish	93,538	24,490	237,131	117	0	355,275	0	776,946
Sharpchin rockfish	23	4	1,876	13,103	19,269	34,276	0	85,672
Redstripe rockfish	3	7	124	18	17,419	17,571	0	42,422
Harlequin rockfish	3,174	221	5,448	1,164	4,933	14,940	0	35,305
Silvergrey rockfish	0	16	44	3,545	20,424	24,029	13,739	34,318
Redbanded rockfish	61	51	308	1,308	4,686	6,414	0	15,068
Splitnose rockfish	0	0	0	1	2	2	0	10
Darkblotched rockfish	0	0	0	84	143	227	0	523
Greenstriped rockfish	0	0	0	8	354	362	137	587
Bocaccio	0	0	0	0	81	81	0	244
Pygmy rockfish	0	0	0	117	24	141	0	397
Yellowmouth rockfish	0	0	0	6	3,346	3,352	0	8,607
Total, other slope	3,260	299	7,800	19,357	70,695	101,411	39,101	163,721
Total, all species	393,238	69,789	664,746	78,468	181,123	1,387,365	744,250	2,030,513

*The 2001 survey did not sample the eastern Gulf of Alaska (the Yakutat and Southeastern areas). Substitute estimates of biomass for the Yakutat and Southeastern areas were obtained by averaging the biomass estimates for species in these areas in the 1993, 1996, and 1999 surveys. In the computations of variance to determine 95% confidence intervals, variance for the Yakutat and Southeastern areas was computed for each species using this formula: (variance of 1993, 1996, and 1999 biomass estimates in each area) x (1 + 1/3).

Table 6-8.--Comparison of biomass estimates (mt) for slope rockfish species in the Gulf of Alaska in the 1984, 1987, 1990, 1993, 1996, 1999, and 2001 trawl surveys. (Biomass estimates for 1993, 1996, and 1999 have been slightly revised from those listed in previous SAFE reports for slope rockfish.) Note: these are estimates of total biomass. For estimates of exploitable biomass for surveys since 1993, see Table 6-18.

Species	1984	1987	1990	1993	1996	1999	2001*
Pacific ocean perch	232,694	214,827	138,003	483,482	771,413	727,263	858,982
Shortraker rockfish	17,721	41,457	10,809	19,710	20,258	28,231	27,929
Rougheye rockfish	46,999	43,929	46,142	61,833	45,913	39,620	43,784
Subtotal, shortraker/rougheye	64,720	85,386	56,951	81,543	66,171	67,850	71,713
Northern rockfish	40,564	140,049	112,948	104,480	98,965	242,187	355,275
Sharpchin rockfish	7,219	70,160	37,050	23,676	64,570	20,841	34,276
Redstripe rockfish	4,803	23,706	24,681	29,619	14,964	8,226	17,571
Harlequin rockfish	2,442	63,833	17,194	9,281	19,974	9,877	14,940
Silvergrey rockfish	4,145	4,710	13,774	18,979	24,127	37,641	24,029
Redbanded rockfish	1,400	1,561	3,173	3,675	4,594	10,941	6,414
Darkblotched rockfish	6	33	184	291	121	272	227
Splitnose rockfish	0	2	3	0	0	7	2
Greenstriped rockfish	16	62	156	268	352	467	362
Vermilion rockfish	0	0	0	20	0	0	0
Bocaccio	502	38	176	106	137	0	81
Pygmy rockfish	0	366	76	3	283	187	141
Yellowmouth rockfish	516	241	1,900	3,563	923	5,570	3,352
Subtotal, other slope rockfish	21,049	164,712	98,367	89,480	130,044	94,027	101,394
Total, all species	359,027	604,974	406,269	758,985	1,066,593	1,131,327	1,387,364

*The 2001 survey did not sample the eastern Gulf of Alaska. Substitute estimates of biomass for this region in 2001 were obtained by averaging the eastern Gulf biomass estimates in the 1993, 1996, and 1999 surveys. These eastern Gulf of Alaska estimates have been included in the 2001 biomass estimates listed in this table.

Table 6-9.--Biomass estimates (mt) and Gulfwide confidence intervals for Pacific ocean perch in the Gulf of Alaska based on the 1984, 1987, 1990, 1993, 1996, 1999, and 2001 trawl surveys. (Biomass estimates and confidence intervals for 1993, 1996, and 1999 have been slightly revised from those listed in previous SAFE reports for slope rockfish.)

	Western	Central		Eastern		Total	95% Confidence interval
	Shumagin	Chirikof	Kodiak	Yakutat	South-eastern		
1984	59,710	9,672	36,976	94,055	32,280	232,694	101,550 - 363,838
1987	62,906	19,666	44,441	35,612	52,201	214,827	125,499 - 304,155
1990	24,375	15,991	15,221	35,635	46,780	138,003	70,993 - 205,013
1993	75,416	103,224	153,262	50,048	101,532	483,482	260,553 - 706,411
1996	92,618	140,479	326,280	50,394	161,641	771,413	355,756 - 1,187,069
1999	38,196	402,293	209,675	32,733	44,367	727,263	0 - 1,566,566
2001*	285,180	39,819	387,078	44,392	102,514	858,982	377,720 - 1,340,244

*The 2001 survey did not sample the eastern Gulf of Alaska (the Yakutat and Southeastern areas). Substitute estimates of biomass for the Yakutat and Southeastern areas were obtained by averaging the biomass estimates for Pacific ocean perch in these areas in the 1993, 1996, and 1999 surveys. The 2001 confidence interval was computed as noted previously in Table 6-7.

Table 6-10 . Survey age composition (% frequency) data for Pacific ocean perch in the Gulf of Alaska. Age compositions for 1978 and 1979 are based on surface reading of otoliths. Age compositions for 1980-99 are based on "break and burn" reading of otoliths.

Age class	Year										
	1978	1979	1980	1981	1982	1984	1987	1990	1993	1996	1999
2	16.08	0.00	0.00	0.14	0.00	0.81	0.73	0.52	0.69	1.72	0.60
3	0.24	0.55	0.39	0.40	0.00	0.53	4.63	6.03	1.97	1.61	2.03
4	1.04	0.81	3.32	5.94	0.17	12.51	6.70	10.90	2.42	3.54	4.54
5	0.63	2.69	5.78	3.42	4.24	2.76	6.18	7.18	7.43	4.25	5.16
6	1.89	5.72	3.01	3.34	8.63	3.82	9.45	12.61	10.98	6.22	2.56
7	6.08	14.52	2.10	2.10	5.27	8.03	19.34	15.54	14.77	3.73	4.06
8	12.02	21.94	7.01	1.34	1.41	38.37	7.30	9.45	11.44	8.72	5.91
9	11.32	17.34	8.37	2.59	3.77	4.01	8.36	7.26	12.77	14.32	9.46
10	9.63	10.72	15.51	6.49	5.47	2.20	10.91	7.88	7.62	18.32	5.40
11	5.42	7.51	9.75	16.93	7.06	0.76	11.40	3.58	4.88	10.91	11.38
12	4.79	4.49	6.40	15.90	11.07	1.98	2.10	2.50	7.55	7.93	14.37
13	5.06	2.72	4.91	5.76	9.52	1.53	1.12	2.55	3.05	3.40	8.61
14	5.44	2.30	2.57	4.19	6.64	1.71	1.02	4.99	1.94	3.60	6.66
15	4.76	1.89	3.24	3.01	4.46	0.66	0.78	1.18	1.82	2.73	4.55
16	4.50	1.66	2.81	1.68	2.39	0.34	0.86	1.01	0.80	0.57	3.99
17	3.57	1.45	1.53	1.03	1.54	1.09	1.27	0.50	3.05	1.27	2.28
18	3.36	1.21	1.69	0.73	1.35	0.71	0.45	0.44	0.62	0.86	1.33
19	2.01	0.91	1.88	1.39	1.00	0.24	0.31	0.47	0.19	1.34	0.32
20	0.92	0.61	1.54	2.75	2.26	0.45	0.36	0.60	0.22	1.29	1.22
21	0.68	0.48	1.83	0.29	1.39	0.39	0.30	0.40	0.14	0.34	0.69
22	0.24	0.28	1.24	0.48	0.79	0.17	0.16	0.15	0.55	0.38	0.79
23	0.12	0.12	0.35	0.70	0.05	0.42	0.18	0.21	0.23	0.25	1.16
24	0.19	0.07	0.86	0.39	0.78	0.20	0.09	0.14	0.33	0.00	0.45
25+	0.00	0.03	13.90	19.01	20.73	16.30	6.00	3.91	4.53	2.69	2.49

Table 6 -11. Observed survey age composition (% frequency) for northern rockfish in the Gulf of Alaska. All age compositions are based on “break and burn” reading of otoliths.

Age class	Year					
	1984	1987	1990	1993	1996	1999
2	0.00	0.00	0.00	0.03	0.28	0.00
3	0.00	0.37	0.06	0.28	0.30	0.03
4	0.00	1.78	0.19	0.31	0.12	0.16
5	1.39	5.53	2.91	0.85	0.21	1.05
6	3.86	4.05	5.41	1.07	1.13	0.27
7	8.39	2.96	2.65	1.08	0.58	0.94
8	17.28	0.28	4.08	6.34	2.06	0.89
9	10.21	2.88	5.38	11.98	4.10	4.23
10	4.78	10.10	4.47	6.54	5.31	2.77
11	4.37	11.21	5.77	10.31	8.52	7.92
12	2.44	11.15	3.52	4.45	7.58	6.92
13	6.81	3.43	5.36	4.90	7.72	5.42
14	6.42	4.28	8.24	4.02	4.02	5.62
15	5.99	1.40	9.71	2.44	3.29	7.82
16	3.82	3.66	5.09	5.19	3.87	9.16
17	1.87	10.31	5.08	3.14	1.65	1.56
18	1.79	4.09	0.67	3.97	3.41	7.21
19	0.55	7.98	1.12	2.81	5.44	1.88
20	0.72	2.72	6.56	0.40	8.78	1.30
21	0.30	2.55	6.63	2.32	2.77	3.00
22	0.95	0.70	4.58	3.41	3.07	2.19
23	3.06	0.65	1.92	4.45	3.02	2.51
24	2.03	0.29	0.89	4.46	3.33	3.03
25+	12.98	7.63	9.71	15.26	19.43	24.12

Table 6-12. Mortality rates, maximum age, and age of recruitment for slope rockfish. Area indicates location of study; West Coast of USA (WC), British Columbia (BC), Gulf of Alaska (GOA), Aleutians (AL), Bering Sea (BS). All mortality rates except where noted are for instantaneous rate of total mortality (Z) estimated with catch-curves.

Species	Mortality rate	Maximum age	Age of recruitment	Area	Reference
Pacific ocean	0.02-0.08	90	-	BC	1,2
perch	-	-	10	GOA	3
	-	84	-	GOA	4
	-	98	-	AL	5
Northern	0.06[a]	44	-	GOA	4
	-	57	-	AL	4
Rougheye	0.01-0.04	140	-	BC	1,2
	0.04	95	30	GOA	6,7
	0.030-0.039[b]	-	-	WC,BS,AL,GOA	8
Shortraker	-	120	-	BC	2
	0.027-0.042[b]	-	-	WC,BS,AL,GOA	8
Sharpchin	0.05	46	-	BC	1
	-	58	-	GOA	4
Yellowmouth	0.06	71	-	BC	1,2
Darkblotched	0.07	48	-	BC	1
Harlequin	-	43	-	BC	2
	-	34	-	GOA	4
Redstripe	0.1	41	-	BC	1,2
Silvergrey	0.01-0.07	80	-	BC	1,2
	-	75	-	GOA	4

1) Archibald et al. 1981; 2) Chilton and Beamish 1982; 3) Heifetz et al. 1994; 4) Malecha and Heifetz 2000; 5) Ito 1987; 6) Nelson and Quinn 1987; 7) Nelson 1986; 8) McDermott 1994. [a]The mortality rate for northern rockfish is for the instantaneous rate of natural mortality (M) estimated by the method of Alverson and Carney (1975). [b]M based on the gonad somatic index method (McDermott 1994).

Table 6-13a. Length-weight coefficients for some species of slope rockfish. Length-weight coefficients are the formula W = aL^b where W = weight in kg and L = length in cm.

Species	Sex	a	b	Reference
Pacific ocean perch	combined	1.54×10^{-5}	2.95	1
	combined	1.91×10^{-5}	2.90	2
	males	1.57×10^{-5}	2.95	2
	females	2.04×10^{-5}	2.89	2
Northern	combined	1.63×10^{-5}	2.98	3
	combined	1.37×10^{-5}	3.04	2
	males	1.55×10^{-5}	2.99	2
	females	1.53×10^{-5}	3.01	2
Rougheye	combined	1.98×10^{-5}	2.94	2
	males	2.04×10^{-5}	2.94	2
	females	1.89×10^{-5}	2.97	2
Sharpchin	combined	1.13×10^{-5}	3.07	2
	males	8.89×10^{-6}	3.15	2
	females	1.19×10^{-5}	3.06	2
Shortraker	combined	9.85×10^{-6}	3.13	2
	males	1.26×10^{-5}	3.07	2
	females	1.02×10^{-5}	3.12	2

1) Ito 1982; 2) Martin 1997; 3) Clausen and Heifetz 1989.

Table 6-13b. Von Bertalanffy parameters for some species of slope rockfish, by area and sex. (BC = British Columbia; GOA = Gulf of Alaska; AL = Aleutian Islands; and BS = Eastern Bering Sea.)

Species	Area	Sex	t_0	k	L_{inf} (cm)	Reference
Pacific ocean perch	BC	combined	-8.22	0.088	44.80	1
	BC	combined	-5.22	0.126	42.60	1
	GOA	combined	-0.32	0.207	41.10	2
	GOA	combined	-0.37	0.204	40.74	3
	GOA	male	-0.29	0.220	39.56	3
	GOA	female	-0.41	0.191	42.00	3
	AL	combined	-0.82	0.169	39.24	3
	BS	combined	-1.66	0.140	39.96	3
Northern	GOA	combined	-1.51	0.190	35.60	2
	GOA	combined	-0.64	0.165	39.16	3
	GOA	male	-0.26	0.187	37.83	3
	GOA	female	-0.87	0.152	40.22	3
	AL	combined	-7.16	0.103	34.27	3
Rougheye	GOA	combined	-4.21	0.050	54.70	4
	GOA	combined	0.63	0.108	49.63	3
	GOA	male	1.14	0.119	49.79	3
	GOA	female	0.18	0.100	49.57	3
Sharpchin	BC	combined	-2.21	0.095	34.90	1
	GOA	combined	-0.81	0.131	32.64	3
	GOA	male	-0.48	0.167	28.44	3
	GOA	female	-0.75	0.122	35.02	3
Silvergray	GOA	combined	-1.68[a]	0.100	59.80	3
	GOA	male	-1.68[a]	0.110	57.14	3
	GOA	female	-1.68[a]	0.093	62.25	3
Harlequin	GOA	combined	-3.86	0.099	31.51	3
	GOA	male	-4.76	0.091	30.60	3
	GOA	female	-3.26	0.110	32.32	3

1) Archibald et al. 1981; 2) Heifetz and Clausen 1991; 3) Malecha and Heifetz 2000; 4) Nelson 1986.

[a] t_0 for silvergray rockfish could not be accurately estimated from the data, therefore t_0 was constrained at the average value for all other rockfish species.

Table 6-14. Estimated time series of female spawning biomass, 6+ biomass (age 6 and greater), catch/6 + biomass, and number of age two recruits for Pacific ocean perch in the Gulf of Alaska. Estimates are shown for the current assessment and from the previous SAFE.

Year	Spawning biomass (mt)		6+ Biomass (mt)		catch/6+ biomass		Age two recruits (1000's)	
	Current	Previous	Current	Previous	Current	Previous	Current	Previous
1977	51,489	23,511	148,200	88,122	0.146	0.245	23,921	6,137
1978	46,419	19,790	132,071	70,455	0.061	0.114	43,853	42,227
1979	46,075	19,600	129,438	64,409	0.065	0.129	63,028	17,917
1980	45,446	19,025	126,628	57,633	0.086	0.187	27,533	8,251
1981	43,603	17,087	122,511	48,348	0.086	0.217	27,544	7,328
1982	41,801	14,492	124,799	49,829	0.044	0.108	49,944	64,403
1983	42,403	14,058	139,038	50,978	0.021	0.055	36,172	12,323
1984	44,848	14,564	147,181	52,093	0.019	0.053	30,150	31,242
1985	47,571	15,221	155,013	52,639	0.005	0.015	37,353	50,482
1986	51,542	16,562	171,071	71,769	0.013	0.031	49,525	66,458
1987	56,014	18,813	182,174	76,463	0.025	0.059	49,881	32,768
1988	60,045	20,138	188,836	83,813	0.046	0.102	133,320	145,799
1989	62,563	20,494	192,875	93,040	0.062	0.127	66,079	94,371
1990	63,716	20,509	197,020	104,721	0.066	0.125	37,889	60,544
1991	64,447	21,175	200,520	106,675	0.033	0.062	35,027	27,417
1992	67,482	24,206	235,470	148,083	0.027	0.042	32,457	73,139
1993	72,603	30,263	255,080	179,706	0.008	0.011	30,978	53,283
1994	79,614	39,156	270,560	206,873	0.007	0.009	29,758	58,370
1995	87,302	49,498	283,729	223,567	0.021	0.026	29,898	50,256
1996	94,210	59,165	290,429	247,165	0.029	0.034	45,090	50,256
1997	100,260	69,235	292,429	261,992	0.033	0.036	45,090	50,256
1998	105,102	78,521	291,581	275,952	0.031	0.032	45,090	50,256
1999	108,677	87,075	290,293	284,337	0.036	0.037	45,090	50,256
2000	110,270	90,757	290,112	290,085	0.035	0.035	45,090	50,256
2001	110,909	95,480	293,420	296,268	0.038		45,090	50,256
2002	107,072		312,240				45,090	

Table 6-15. Estimated numbers (thousands) in 2002, fishery selectivity, and survey selectivity of Pacific ocean perch in the Gulf of Alaska. Also shown are schedules of age specific weight and female maturity.

Age	Numbers in 2002 (1000's)	Percent mature	Weight (g)	Fishery selectivity	Survey selectivity
2	45,090	0	53	0	8
3	67,004	0	116	1	17
4	62,495	0	194	4	34
5	46,732	0	279	11	60
6	44,097	0	363	30	87
7	45,346	12	442	66	100
8	34,341	20	515	100	99
9	23,256	30	579	100	98
10	21,208	42	635	99	97
11	20,263	56	683	99	97
12	19,560	69	724	99	97
13	19,512	79	759	99	97
14	19,637	87	788	99	97
15	32,058	92	812	99	97
16	60,469	95	832	99	97
17	20,894	97	848	99	97
18	18,863	98	861	99	97
19	12,777	99	872	99	97
20	9,217	99	881	99	97
21	10,024	100	889	99	97
22	12,766	100	895	99	97
23	6,575	100	900	99	97
24	6,158	100	904	99	97
25+	13,124	100	907	99	97

Table 6 -16. Estimated time series of female spawning biomass, 6+ biomass (age 6 and greater), catch/(6+ biomass), and the number of age two recruits for northern rockfish in the Gulf of Alaska based an age structured model.

Year	Spawning biomass (mt)		6+ Total Biomass (mt)		Catch / (6+ Total biomass)		Age two recruits (1000's)	
	Current	Previous	Current	Previous	Current	Previous	Current	Previous
1977	24,561	24,803	93,550	92,655	0.007	0.007	34,467	37,392
1978	25,420	25,565	95,106	93,936	0.006	0.006	65,016	55,369
1979	26,743	26,782	100,622	99,414	0.007	0.007	23,400	29,396
1980	28,451	28,374	102,320	100,555	0.008	0.008	10,843	8,484
1981	30,456	30,257	108,741	107,469	0.014	0.014	10,389	10,108
1982	32,467	32,145	121,310	117,982	0.032	0.033	20,512	22,854
1983	33,753	33,311	123,833	121,479	0.029	0.029	24,704	18,368
1984	35,060	34,507	123,614	120,721	0.008	0.008	34,532	38,873
1985	37,137	36,470	125,108	122,072	0.001	0.001	16,923	12,867
1986	39,450	38,670	128,814	126,227	0.002	0.002	58,457	54,896
1987	41,693	40,806	132,995	129,123	0.003	0.004	19,669	20,674
1988	43,816	42,824	138,927	135,858	0.008	0.008	11,748	9,160
1989	45,620	44,529	140,629	136,764	0.011	0.011	20,054	17,824
1990	47,146	45,963	150,367	145,691	0.011	0.012	18,484	15,443
1991	48,459	47,186	152,674	148,078	0.030	0.030	3,114	3,108
1992	48,598	47,236	150,017	144,824	0.052	0.052	15,134	12,579
1993	47,510	46,049	145,373	139,613	0.033	0.034	2,178	2,174
1994	47,275	45,698	142,913	136,398	0.042	0.043	4,664	3,779
1995	46,568	44,852	135,872	129,212	0.041	0.043	3,382	3,814
1996	45,835	43,961	131,068	123,802	0.026	0.027	17,540	10,797
1997	45,700	43,651	125,618	118,233	0.023	0.025	17,540	16,400
1998	45,463	43,260	120,587	113,022	0.025	0.027	17,540	16,400
1999	44,864	42,521	114,873	107,450	0.047	0.049	17,540	16,400
2000	42,982	40,533	108,775	100,953	0.031	0.033	17,540	16,400
2001	41,615	39,088	103,005	97,815	0.030		17,540	16,400
2002*	40,067		97,446				17,540	

* projection based on an average recruitment 1977-1993 year class.

Table 6-17. Estimated numbers (thousands) in 2002, fishery selectivity (assumed equal to survey selectivity) of northern rockfish in the Gulf of Alaska based on an age structured model. Also shown are schedules of age specific weight and female maturity.

Age	Numbers in 2002 (1000's)	Percent mature	Weight (g)	Fishery/Survey selectivity
2	17,540	1	63	2
3	7,351	2	103	4
4	6,917	3	153	8
5	4,338	4	210	15
6	3,312	6	273	25
7	2,964	9	336	37
8	8,994	13	399	53
9	2,113	18	458	73
10	2,677	25	512	90
11	1,141	33	561	100
12	7,205	43	603	100
13	1,347	52	641	100
14	7,274	62	672	100
15	7,178	71	699	100
16	3,816	78	722	100
17	5,794	84	740	100
18	15,647	89	756	100
19	4,133	92	769	100
20	7,742	95	780	100
21	5,118	96	788	100
22	3,953	97	795	100
23+	48,173	98	801	100

Table 6-18.--Estimates of exploitable biomass of shortraker and rougheye rockfish and other slope rockfish in the Gulf of Alaska, by NPFMC regulatory area, based on the 1993 - 2001 triennial trawl surveys. Results of the age structured modeling are used to determine exploitable biomass of Pacific ocean perch and northern rockfish.

	Exploitable biomass (mt)			
Species	Western	Central	Eastern	Total
		1993		
Shortraker rockfish	2,726	7,636	8,588	18,950
Rougheye rockfish	11,230	42,326	9,854	63,410
Subtotal, shortraker/rougheye	13,956	49,962	18,442	82,360
Sharpchin rockfish	22	7,943	14,490	22,455
Redstripe rockfish	0	111	26,620	26,731
Harlequin rockfish	30	8,060	530	8,619
Silvergrey rockfish	0	448	16,433	16,880
Redbanded rockfish	11	444	3,089	3,544
Minor species	0	0	4,105	4,105
Subtotal, other slope rockfish	63	17,006	65,267	82,334
		1996		
Shortraker rockfish	1,906	10,134	8,221	20,261
Rougheye rockfish	3,404	27,405	13,803	44,612
Subtotal, shortraker/rougheye	5,310	37,539	22,024	64,873
Sharpchin rockfish	39	2,015	62,579	64,633
Redstripe rockfish	0	89	14,722	14,811
Harlequin rockfish	772	1,937	16,372	19,081
Silvergrey rockfish	0	1,555	22,478	24,033
Redbanded rockfish	61	203	4,298	4,562
Minor species	152	20	4,036	4,208
Subtotal, other slope rockfish	1,024	5,819	124,485	131,328
		1999		
Shortraker rockfish	2,208	12,391	13,633	28,232
Rougheye rockfish	6,036	18,781	12,373	37,189
Subtotal, shortraker/rougheye	8,244	31,172	26,005	65,421
Sharpchin rockfish	0	2,857	17,985	20,842
Redstripe rockfish	0	125	8,077	8,201
Harlequin rockfish	7	8,560	1,307	9,874
Silvergrey rockfish	0	6,746	30,755	37,500
Redbanded rockfish	118	404	10,421	10,943
Minor species	0	6	6,483	6,489
Subtotal, other slope rockfish	126	18,698	75,027	93,850

Table 6-18.– (Continued).

Species	Exploitable biomass (mt) Western	Central	Eastern	Total
		2001*		
Shortraker rockfish	4,313	13,117	10,499	27,929
Rougheye rockfish	6,851	23,366	11,818	42,035
Subtotal, shortraker/rougheye	11,164	36,484	22,317	69,964
Sharpchin rockfish	23	1,880	32,372	34,276
Redstripe rockfish	0	131	17,433	17,564
Harlequin rockfish	3172	5,625	6098	14,894
Silvergrey rockfish	0	16	23,888	23,095
Redbanded rockfish	61	309	5,983	6,352
Minor species	0	0	4,160	4,160
Subtotal, other slope rockfish	3256	7,961	89,934	101,151

* Values for Eastern Gulf are the averages of 93, 96, and 99 values.

Table 6-19. Set of projections of spawning biomass (SB) and yield for Pacific ocean perch in the Gulf of Alaska . This set of projections encompasses seven harvest scenarios is designed to satisfy the requirements of Amendment 56, the National Environmental Protection Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA). For a description of scenarios see section 6.7.1. All units in mt. $B_{40\%}$ = 98,793 mt, $B_{35\%}$ = 86,444 mt, $F_{40\%}$ = 0.050, and $F_{35\%}$ = 0.059.

Year	Maximum permissible F	Author's F	Half maximum F	5-year average F	No fishing	Overfished	Approaching overfished?
Spawning biomass (mt)							
2001	107,600	107,600	107,600	107,600	107,600	107,600	107,600
2002	107,072	107,072	107,950	107,771	108,836	106,734	107,072
2003	105,720	105,720	109,209	108,491	112,813	104,402	105,720
2004	104,458	104,458	110,516	109,258	116,929	102,207	104,128
2005	103,837	103,837	112,435	110,632	121,756	100,696	102,544
2006	103,776	103,776	114,885	112,534	127,213	99,783	101,548
2007	104,024	104,024	117,633	114,728	133,083	99,209	100,883
2008	104,460	104,460	120,530	117,070	139,181	98,866	100,431
2009	105,005	105,005	123,481	119,470	145,387	98,688	100,123
2010	105,494	105,494	126,292	121,741	151,465	98,519	99,810
2011	105,760	105,760	128,756	123,687	157,154	98,205	99,347
2012	105,752	105,752	130,798	125,235	162,333	97,708	98,707
2013	105,537	105,537	132,475	126,450	167,040	97,098	97,963
2014	105,182	105,182	133,851	127,395	171,323	96,439	97,183
Fishing mortality							
2001	0.041	0.041	0.041	0.041	0.041	0.041	0.041
2002	0.050	0.050	0.025	0.030	0.000	0.059	0.050
2003	0.050	0.050	0.025	0.030	0.000	0.059	0.050
2004	0.050	0.050	0.025	0.030	0.000	0.059	0.059
2005	0.050	0.050	0.025	0.030	0.000	0.059	0.059
2006	0.050	0.050	0.025	0.030	0.000	0.059	0.059
2007	0.050	0.050	0.025	0.030	0.000	0.059	0.059
2008	0.050	0.050	0.025	0.030	0.000	0.059	0.059
2009	0.050	0.050	0.025	0.030	0.000	0.059	0.059
2010	0.050	0.050	0.025	0.030	0.000	0.059	0.059
2011	0.050	0.050	0.025	0.030	0.000	0.059	0.059
2012	0.050	0.050	0.025	0.030	0.000	0.058	0.059
2013	0.050	0.050	0.025	0.030	0.000	0.058	0.058
2014	0.050	0.050	0.025	0.030	0.000	0.057	0.058
Yield (mt)							
2001	10,972	10,972	10,972	10,972	10,972	10,972	10,972
2002	13,193	13,193	6,674	8,011	0	15,672	13,193
2003	13,236	13,236	6,851	8,185	0	15,584	13,236
2004	13,303	13,303	7,035	8,368	0	15,535	15,803
2005	13,451	13,451	7,255	8,595	0	15,589	15,839
2006	13,644	13,644	7,494	8,844	0	15,704	15,934
2007	13,731	13,731	7,675	9,026	0	15,700	15,912
2008	13,694	13,694	7,786	9,124	0	15,522	15,752
2009	13,646	13,646	7,882	9,207	0	15,335	15,582
2010	13,594	13,594	7,969	9,280	0	15,150	15,392
2011	13,537	13,537	8,046	9,342	0	14,953	15,179
2012	13,476	13,476	8,112	9,393	0	14,743	14,946
2013	13,410	13,410	8,169	9,436	0	14,532	14,711
2014	13,345	13,345	8,222	9,475	0	14,335	14,492

Table 6-20. Percentage of exploitable biomass by area for slope rockfish based on the 1993, 96, 99 and 2001 triennial trawl surveys. Weighted average uses weights of 4:6:9 for the 1996, 1999,and 2001 survey, respectively.

	Western	Central	Eastern
1993			
Pacific ocean perch	16.67%	56.26%	27.12%
Rougheye/shortraker rockfish	16.95%	60.66%	22.34%
Northern rockfish	3.71%	96.25%	0.04%
Other slope rockfish	0.08%	20.65%	79.27%
1996			
Pacific ocean perch	11.48%	61.11%	27.41%
Rougheye/shortraker rockfish	8.19%	57.87%	33.95%
Northern rockfish	26.28%	73.51%	0.21%
Other slope rockfish	0.78%	4.43%	94.79%
1999			
Pacific ocean perch	5.00%	84.37%	10.63%
Rougheye/shortraker rockfish	12.60%	47.65%	39.75%
Northern rockfish	6.78%	93.18%	0.04%
Other slope rockfish	0.13%	19.92%	79.94%
2001*			
Pacific ocean perch	33.37%	48.28%	18.35%
Rougheye/shortraker rockfish	15.96%	52.15%	31.90%
Northern rockfish	17.83%	82.14%	0.03%
Other slope rockfish	3.22%	7.87%	88.91%
Weighted average			
Pacific ocean perch	19.85%	62.28%	17.87%
Rougheye/shortraker rockfish	13.31%	51.91%	34.78%
Northern rockfish	16.16%	83.76%	0.08%
Other slope rockfish	1.73%	10.95%	87.31%

* Values for Eastern Gulf are the averages of 93, 96, 99 values.

Table 6-21. Northern rockfish spawning biomass, fishing mortality, and yield for seven harvest scenarios. B40% = 23,330 mt, B35% = 21,410 mt, F40% = 0.056, F35% = 0.067.

Year	Maximum permissible F	Author's F	Half maximum F	5-year average F	No fishing	Overfished	Approaching overfished?
Spawning biomass (mt)							
2001	41,615	41,615	41,615	41,615	41,615	41,615	41,615
2002	40,067	40,067	40,067	40,067	40,067	40,067	40,067
2003	37,528	37,528	38,580	38,718	39,662	37,132	37,528
2004	35,022	35,022	37,005	37,268	39,101	34,289	35,022
2005	32,610	32,610	35,403	35,779	38,437	31,597	32,266
2006	30,344	30,344	33,829	34,306	37,722	29,104	29,712
2007	28,286	28,286	32,356	32,922	37,028	26,865	27,415
2008	26,445	26,445	31,000	31,642	36,371	24,884	25,380
2009	24,879	24,879	29,839	30,549	35,843	23,211	23,656
2010	23,605	23,605	28,907	29,676	35,491	21,871	22,255
2011	22,623	22,623	28,213	29,036	35,339	20,900	21,222
2012	21,948	21,948	27,762	28,635	35,406	20,252	20,522
2013	21,553	21,553	27,551	28,474	35,709	19,882	20,108
2014	21,375	21,375	27,538	28,510	36,210	19,726	19,912
Fishing mortality							
2001	0.033	0.033	0.033	0.033	0.033	0.033	0.033
2002	0.056	0.056	0.028	0.024	0.000	0.067	0.056
2003	0.056	0.056	0.028	0.024	0.000	0.067	0.056
2004	0.056	0.056	0.028	0.024	0.000	0.067	0.067
2005	0.056	0.056	0.028	0.024	0.000	0.067	0.067
2006	0.056	0.056	0.028	0.024	0.000	0.067	0.067
2007	0.056	0.056	0.028	0.024	0.000	0.067	0.067
2008	0.056	0.056	0.028	0.024	0.000	0.067	0.067
2009	0.056	0.056	0.028	0.024	0.000	0.066	0.066
2010	0.055	0.055	0.028	0.024	0.000	0.062	0.063
2011	0.053	0.053	0.028	0.024	0.000	0.059	0.060
2012	0.052	0.052	0.028	0.024	0.000	0.057	0.058
2013	0.051	0.051	0.028	0.024	0.000	0.056	0.057
2014	0.050	0.050	0.028	0.024	0.000	0.055	0.056
Yield (mt)							
2001	3,120	3,120	3,120	3,120	3,120	3,120	3,120
2002	4,979	4,979	2,523	2,202	0	5,905	4,979
2003	4,619	4,619	2,405	2,107	0	5,422	4,619
2004	4,295	4,295	2,296	2,018	0	4,991	5,094
2005	4,006	4,006	2,197	1,937	0	4,610	4,703
2006	3,754	3,754	2,109	1,865	0	4,281	4,364
2007	3,560	3,560	2,043	1,813	0	4,026	4,100
2008	3,424	3,424	2,003	1,781	0	3,845	3,912
2009	3,346	3,346	1,988	1,772	0	3,691	3,786
2010	3,290	3,290	1,995	1,781	0	3,456	3,560
2011	3,187	3,187	2,015	1,802	0	3,307	3,394
2012	3,114	3,114	2,040	1,827	0	3,226	3,297
2013	3,083	3,083	2,068	1,854	0	3,200	3,258
2014	3,084	3,084	2,097	1,883	0	3,212	3,259

Table 6-22. Set of projections of yield for slope rockfish for 2002 in the Gulf of Alaska. This set of projections encompasses scenarios designed to satisfy the requirements of Amendment 56, the National Environmental Protection Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA). For a description of scenarios see section 6.7.1. All units in mt.

	Exploitable	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
Species	Biomass	F	Yield	F	Yield	F	Yield	F	Yield
Shortraker	25,473	0.0225	573	0.0225	573	0.0113	287		
Rougheye	41,356	0.0320	1,323	0.0250	1,034	0.0160	662		
Total shortraker rougheye	66,829		1,896		1,607		949	0.025	1,671
Sharpchin	39,884	0.053	2,114	0.050	1,994	0.027	1,077		
Redstripe	13,576	0.075	1,018	0.075	1,018	0.038	516		
Harlequin	14,594	0.045	657	0.045	657	0.023	336		
Silvergrey	28,477	0.030	854	0.030	854	0.015	427		
Redbanded	7,284	0.045	328	0.045	328	0.023	168		
Minor spp	4,147	0.045	187	0.045	187	0.023	96		
Total other slope rockfish	**107,962**		**5,157**		**5,038**		**2,618**	**0.010**	**1,012**

Table 6-23. Summary of computations of ABC's and overfishing levels for slope rockfish for 2002. Since ABC's and overfishing levels are based on subgroups, individual species are shown only for illustrative purposes.

Species	Exploitable biomass (mt)	ABC F	ABC Yield (mt)	Overfishing F	Overfishing Yield (mt)
Pacific ocean perch	293,243	$F=F_{40\%}$=.050	13,190	F=F35%=0.059	15,670
Shortraker rockfish	25,473	F=0.75M=0.023	586	F=M=0.030	764
Rougheye rockfish	41,356	F=M=0.025	1,034	F35%=0.038	1,579
Subtotal rougheye/shortraker	66,829		1,620		2,343
Northern rockfish	93,850	$F=F_{40\%}$=0.056	4,980	F35%=0.067	5,910
Sharpchin rockfish	39,884	F=M=0.050	1,994	F35%=0.064	2,553
Redstripe rockfish	13,576	F=0.75M=0.075	1,018	F=M=0.100	1,358
Harlequin rockfish	14,594	F=0.75M=0.045	657	F=M=0.060	876
Silvergrey rockfish	28,477	F=0.75M=0.030	854	F=M=0.040	1,139
Redbanded rockfish	7,284	F=0.75M=0.045	328	F=M=0.060	437
Minor species	4,147	F=0.75M=0.045	187	F=M=0.060	249
Subtotal other slope rockfish	107,962		5,038		6,612
Total	495,055		24,815		30,525

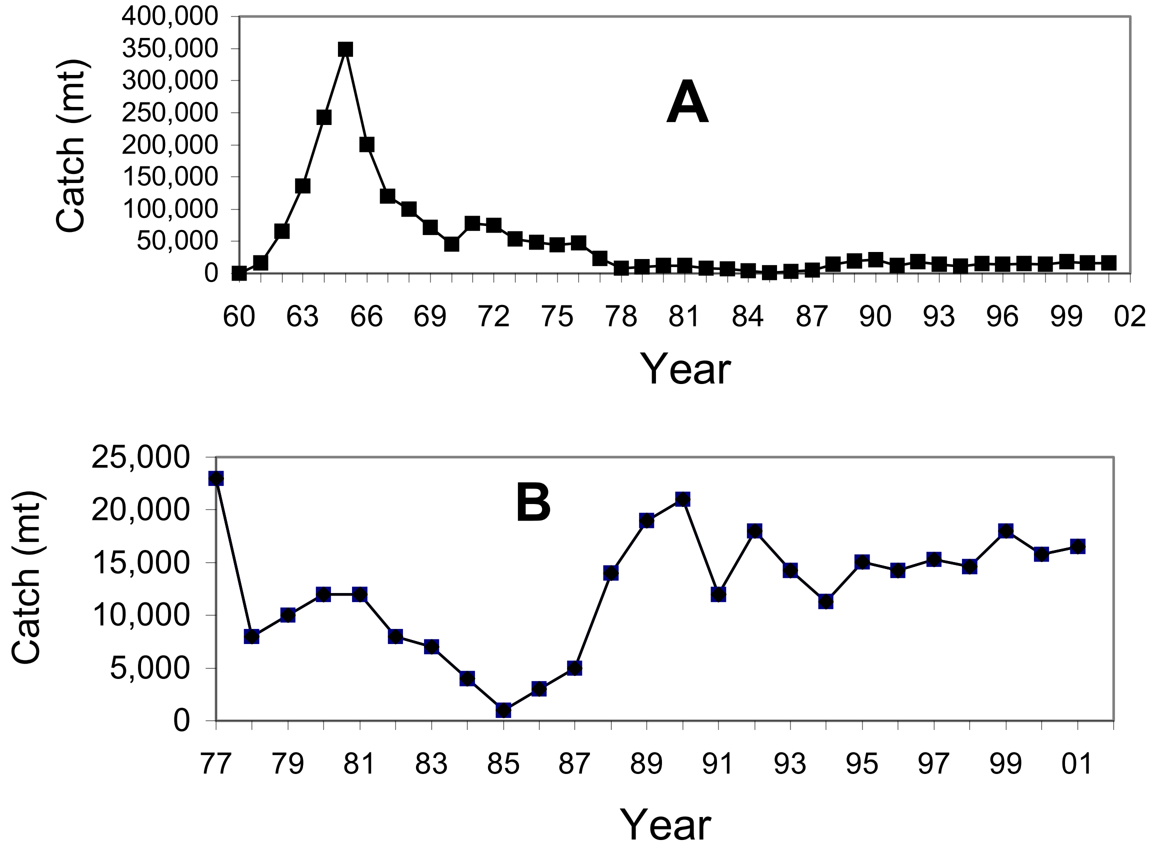

Figure 6 -1. All nation catch of Pacific ocean perch and slope rockfish in the Gulf of Alaska as of October 6, 2001. Long term catch history is shown in the upper panel and recent catch history is shown in the lower panel.

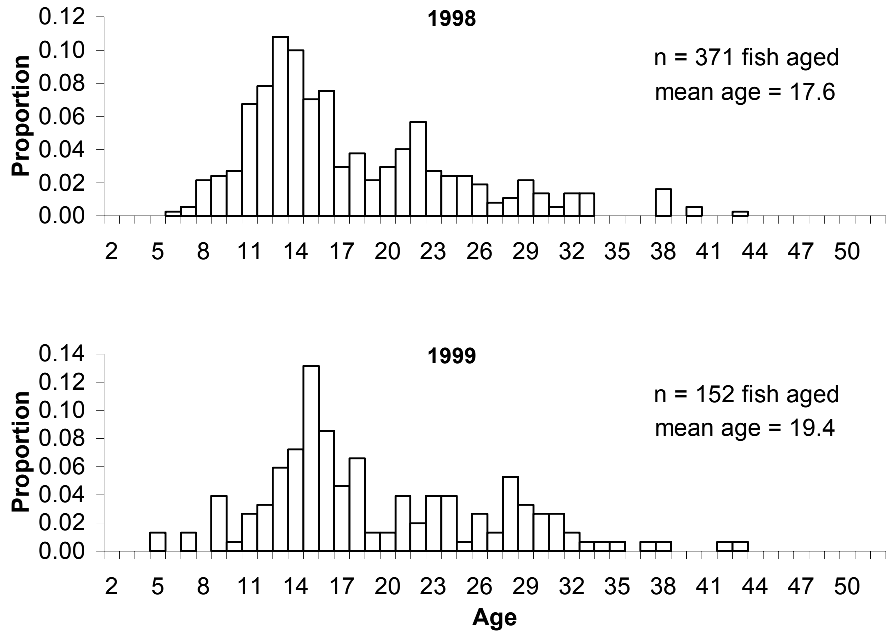

Figure 6-2. Age composition of northern rockfish in the Gulf of Alaska based on 1998 and 1999 fishery data.

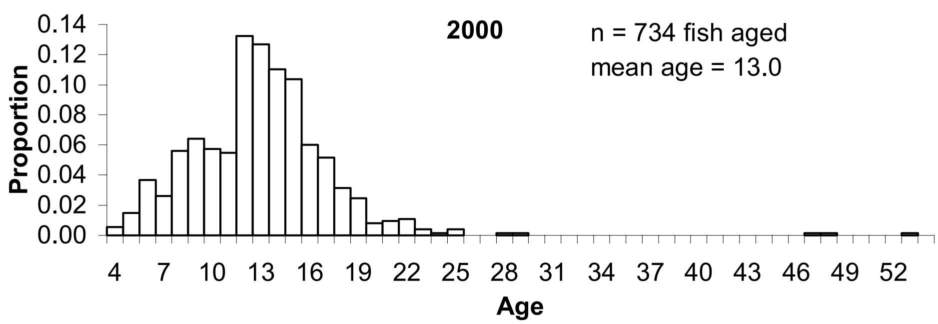

Figure 6-3. Age composition of Pacific ocean perch in the Gulf of Alaska based on the 2000 fishery data.

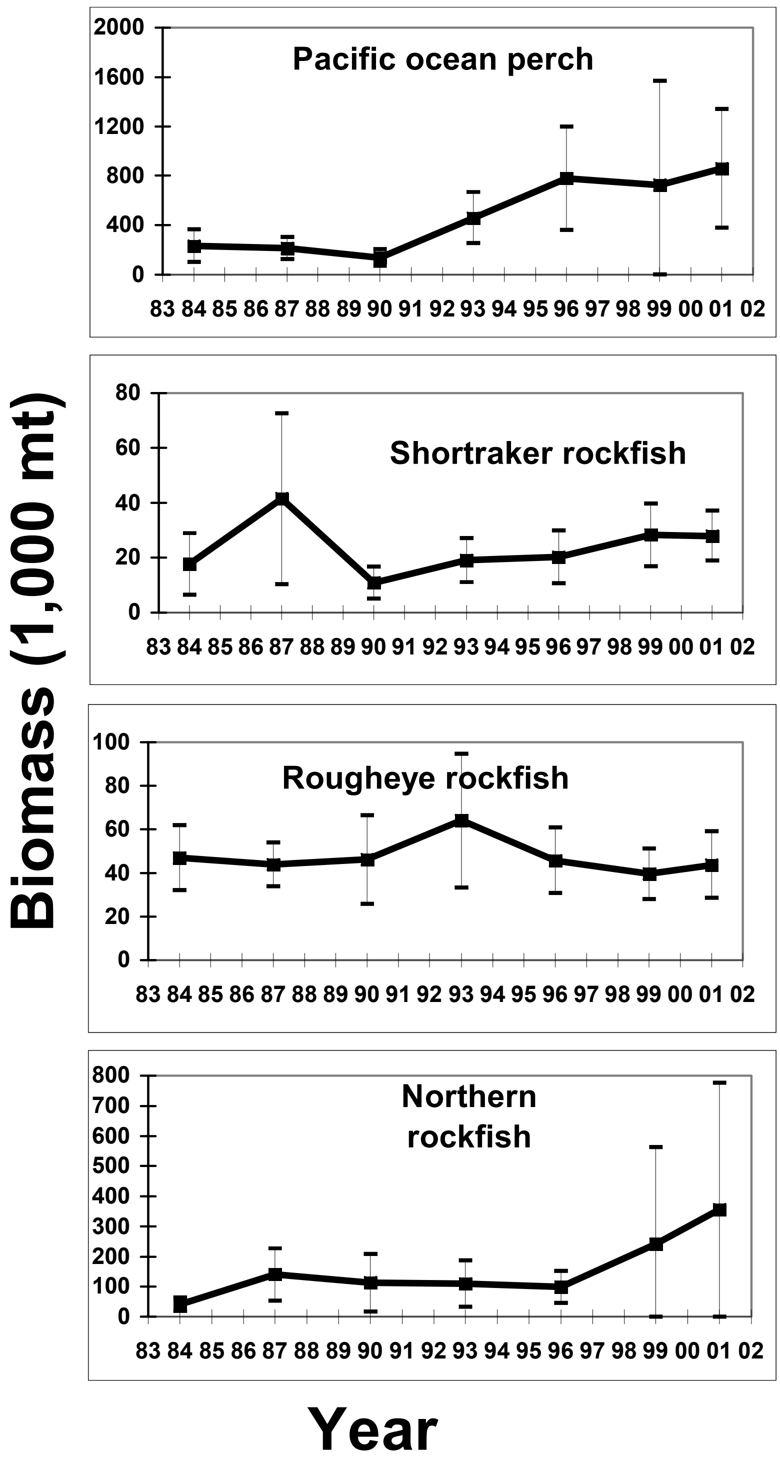

Figure 6-4. Estimated biomass of Pacific ocean perch, shortraker rockfish, rougheye rockfish, and northern rockfish in the Gulf of Alaska, based on results of the 1984, 1987, 1990, 1993, 1996, 1999, and 2001 trawl surveys. The vertical bars show 95% confidence limits associated with each estimate.

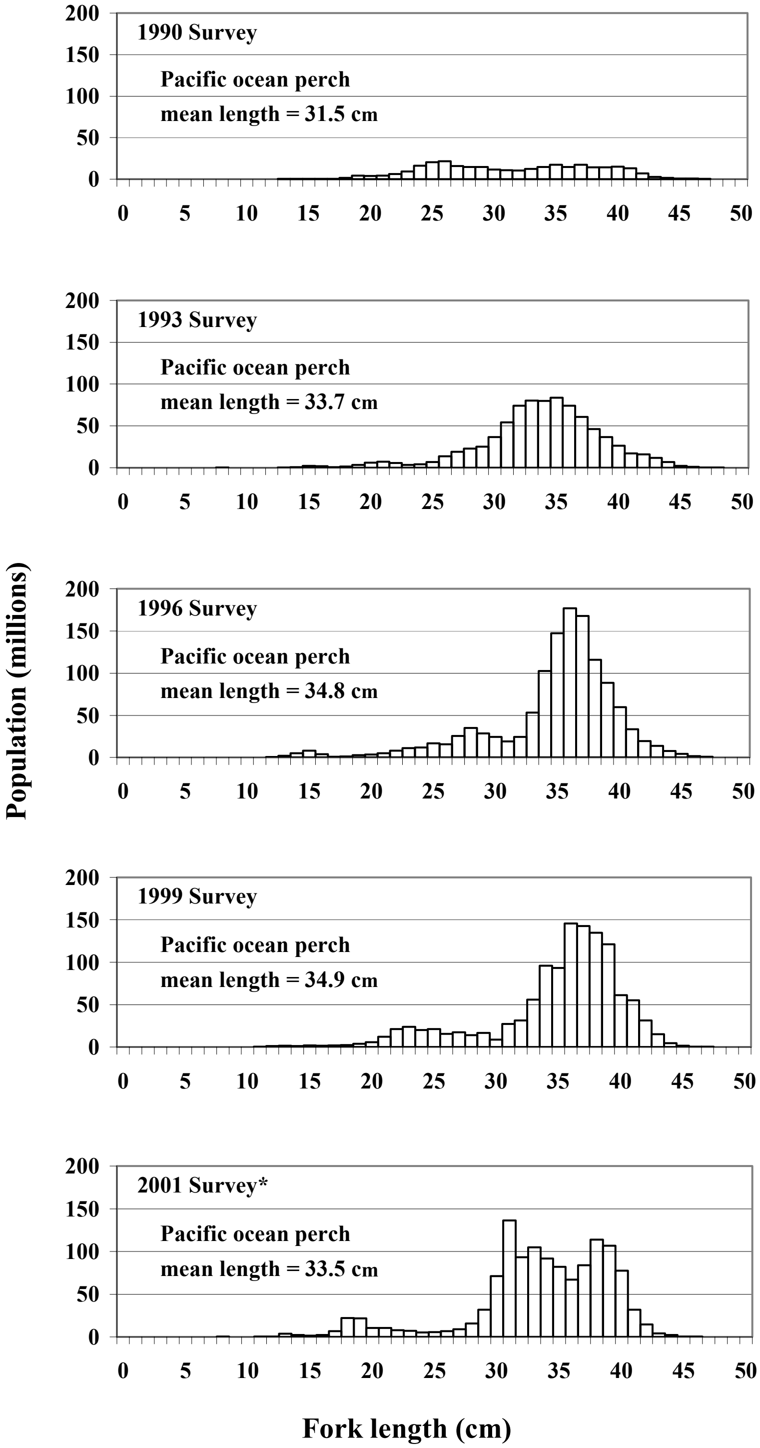

Figure 6-5. Length frequency distribution of the estimated population of Pacific ocean perch in the Gulf of Alaska, based on the 1990, 1993, 1996, 1999, and 2001 trawl surveys. *2001 survey did not sample the eastern Gulf of Alaska.

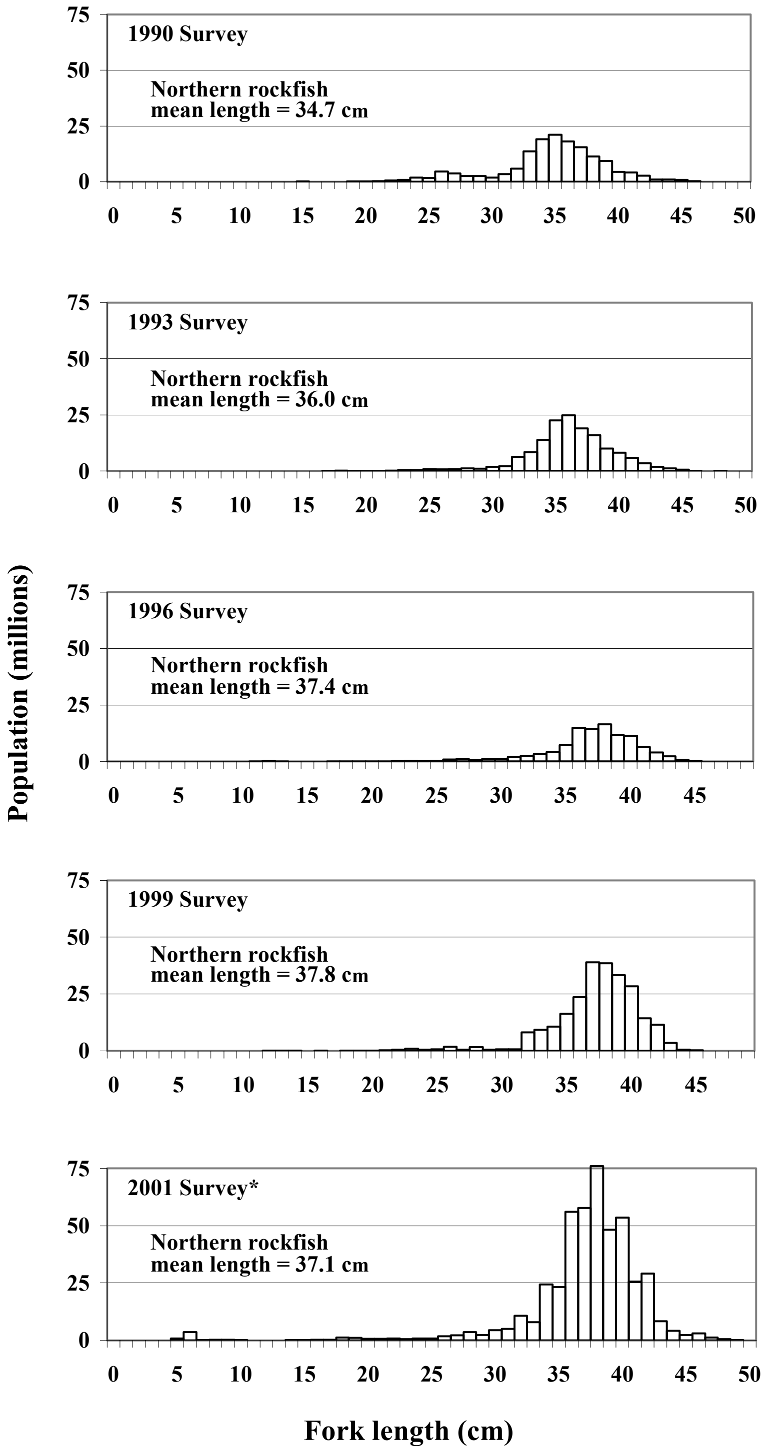

Figure 6-6. Length frequency distribution of the estimated population of northern rockfish in the Gulf of Alaska, based on the 1990, 1993, 1996, 1999, and 2001 trawl surveys. *2001 survey did not sample the eastern Gulf of Alaska.

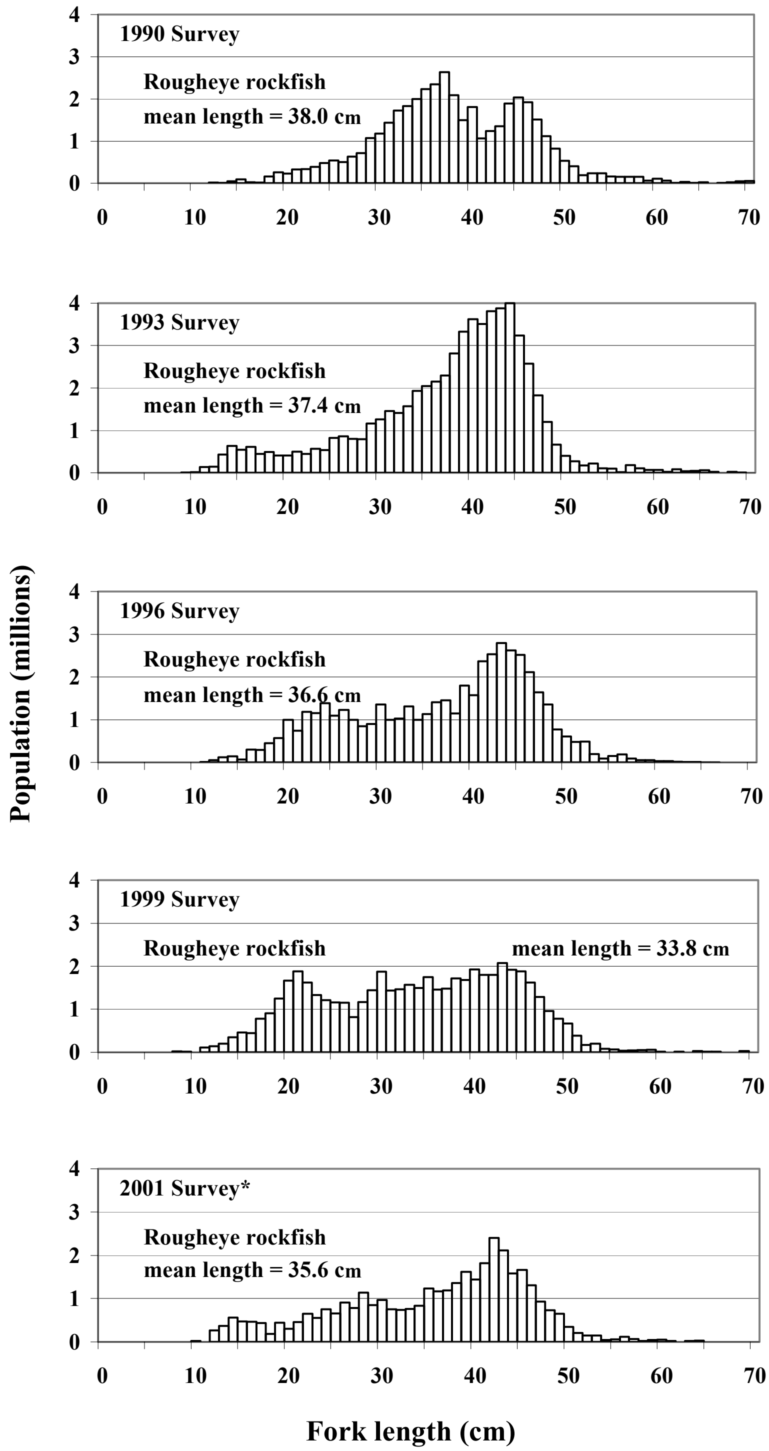

Figure 6-7. Length frequency distribution of the estimated population of rougheye rockfish in the Gulf of Alaska, based on the 1990, 1993, 1996, 1999, and 2001 trawl surveys. *2001 survey did not sample the eastern Gulf of Alaska.

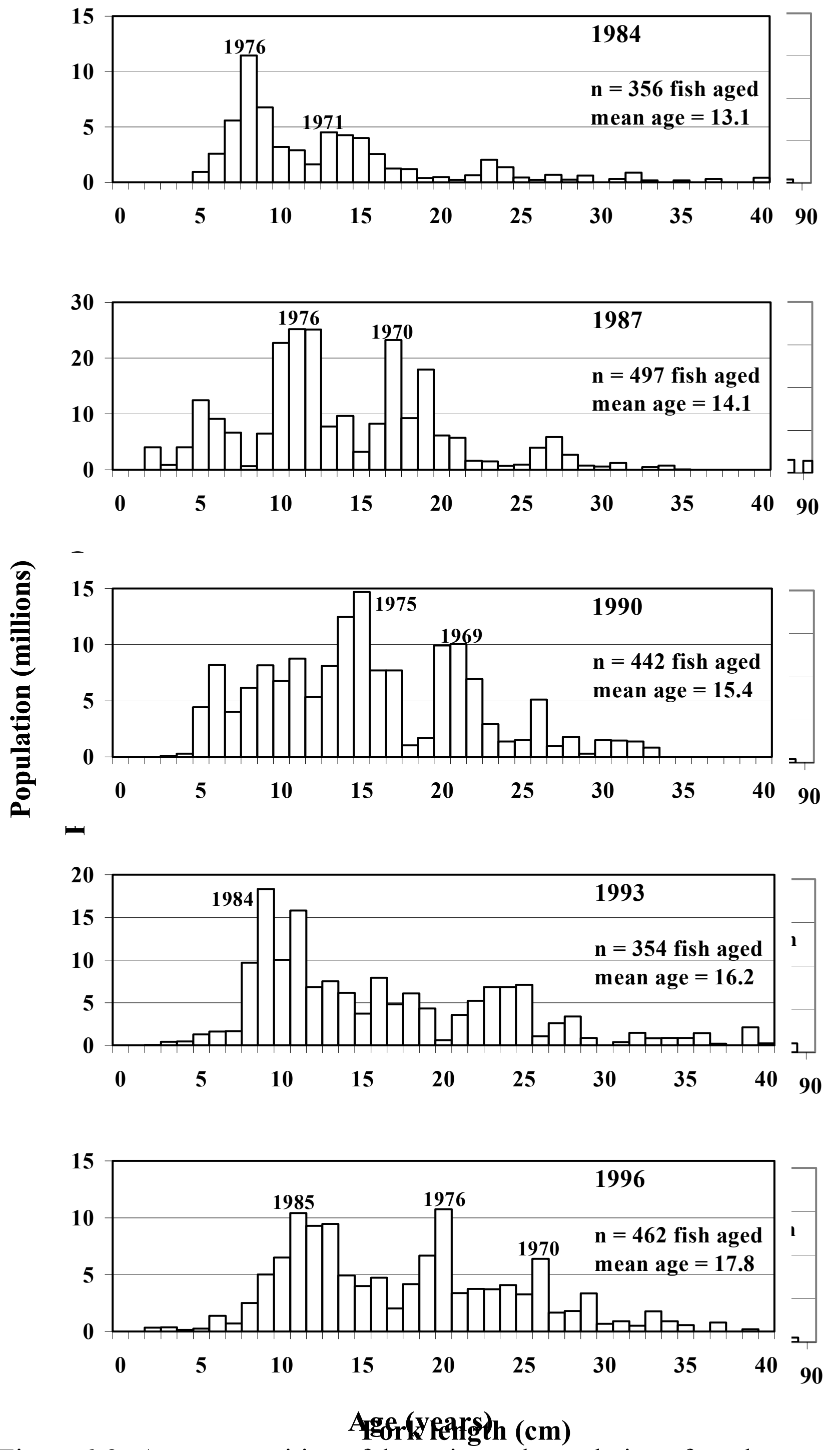

Figure 6-9. Age composition of the estimated population of northern rockfish in the Gulf of Alaska based on the 1984, 1987, 1990, 1993, 1996, and 1999 triennial trawl surveys. The numbers next to prominent bars identify year classes that may be strong. (Figure is continued on next page.)

Figure 6-8. Length frequency distribution of the estimated population of shortraker rockfish in the Gulf of Alaska, based on the 1990, 1993, 1996, 1999, and 2001 trawl surveys. *2001 survey did not sample the eastern Gulf of Alaska.

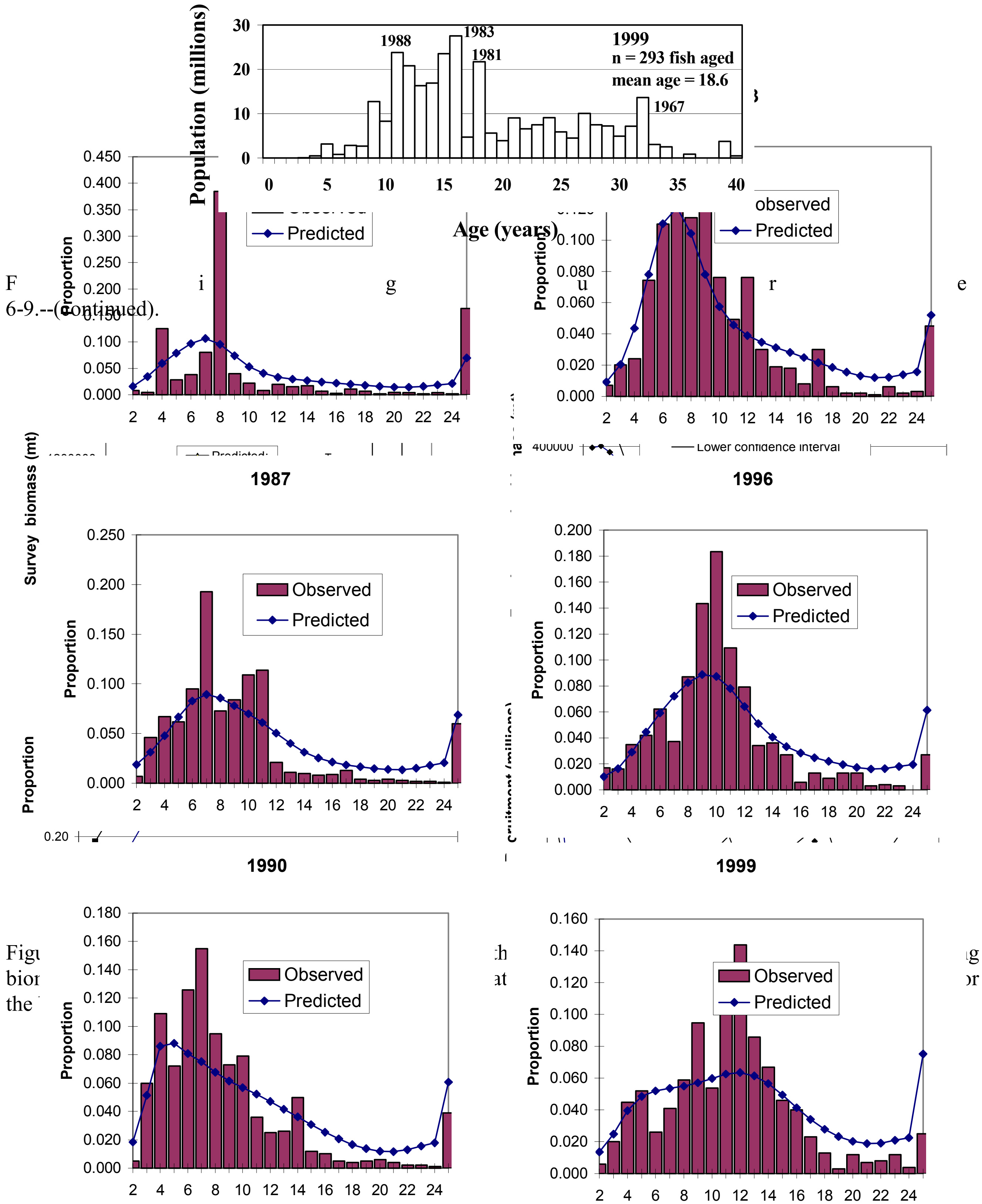

Figure 6-11. Observed and predicted survey age composition for Pacific ocean perch in the Gulf of Alaska based on the base model.

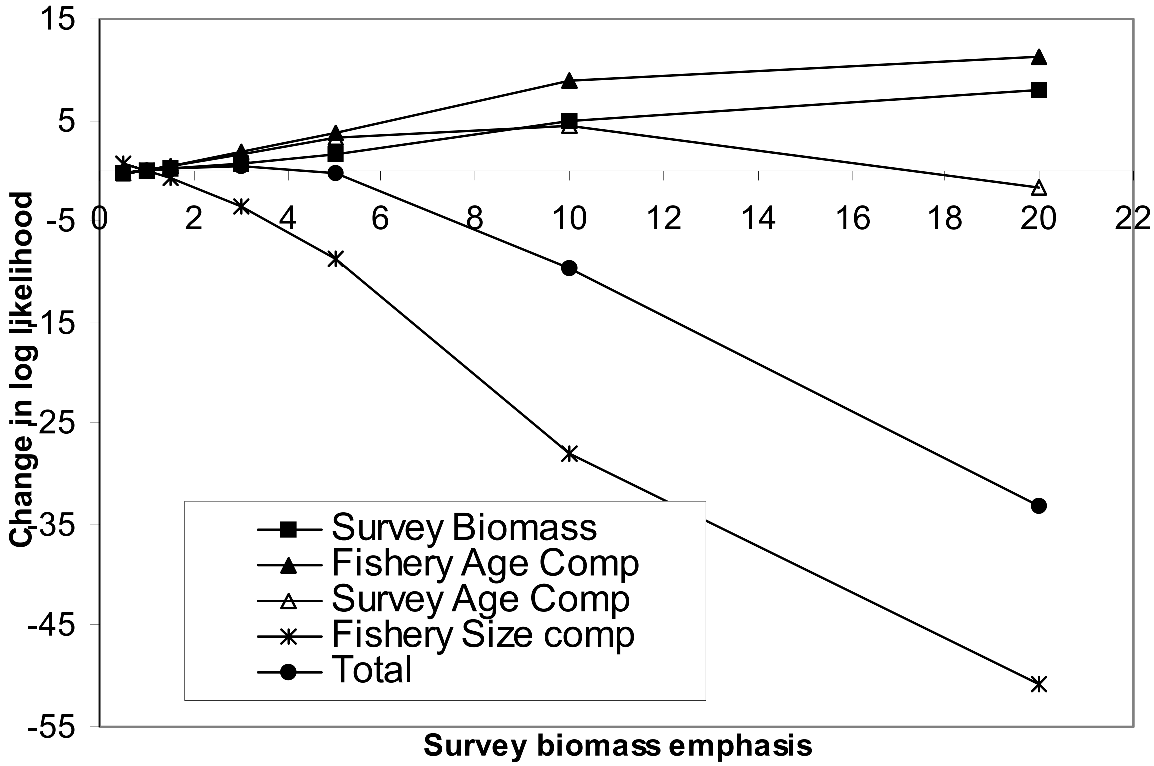

Figure 6-12. Relationship between the change in log likelihood values and emphasis on survey biomass for Pacific ocean perch in the Gulf of Alaska. A positive change indicates an improved fit to a particular data component.

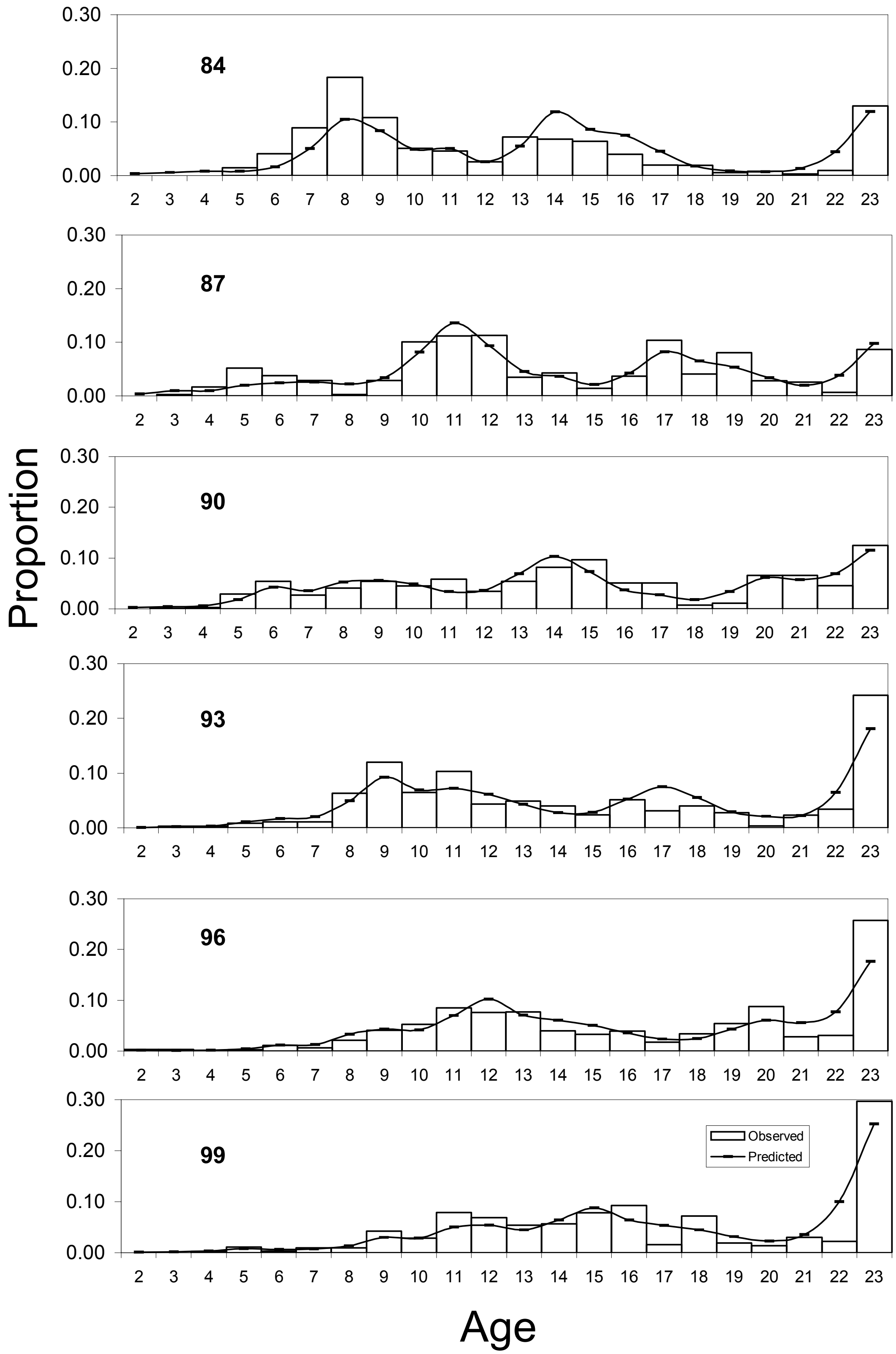

Figure 6 – 13 . Observed and predicted triennial survey age composition for northern rockfish in the Gulf of Alaska based on the age structured model.

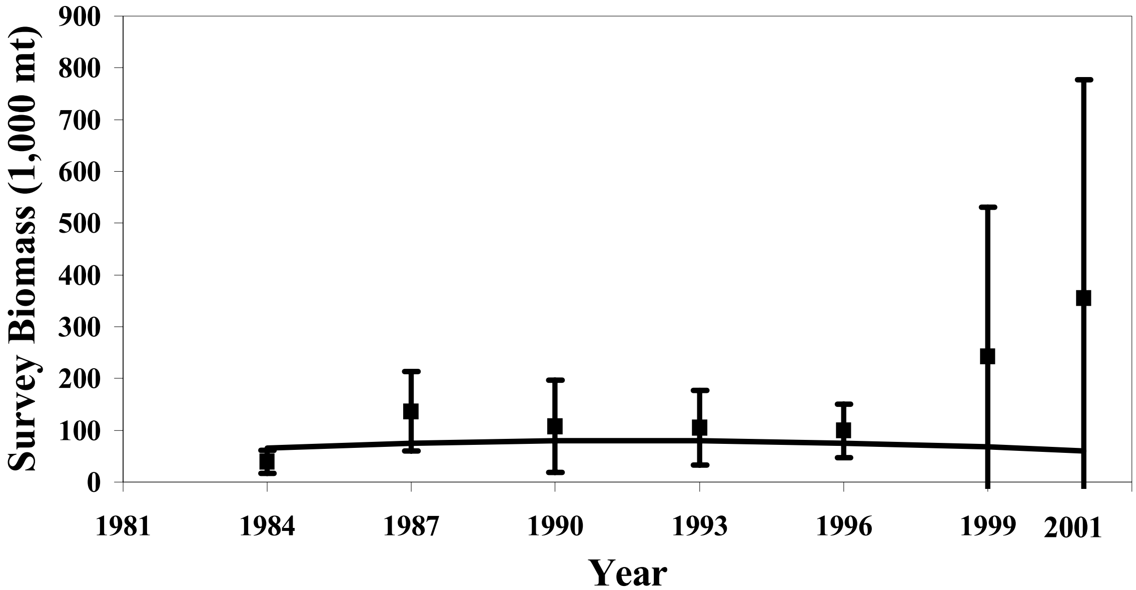

Figure 6-14. Observed and predicted survey biomass for northern rockfish in the Gulf of Alaska based on an age structured model. Ninety-five percent confidence limit is shown for each observed biomass estimate.

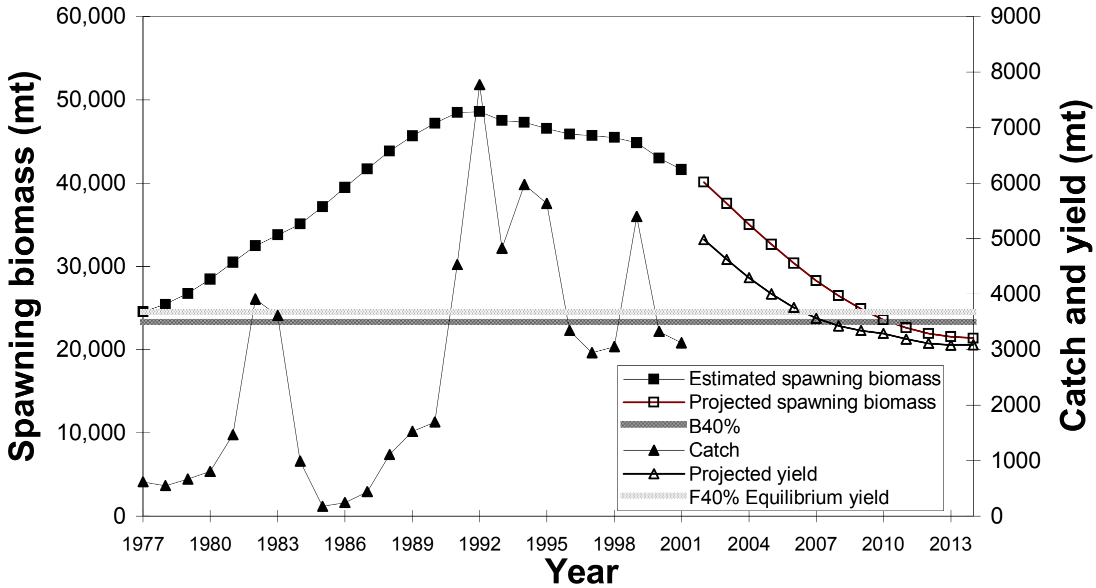

Figure 6-15. Recent trend and long-term projection of spawning biomass and yield of northern rockfish in the Gulf of Alaska based on tier 3 computations. At average recruitment (based on 1977-1993 year classes) the spawning biomass is projected to fall below $B_{40\%}$ in 2011 and the catch is projected to fall below $F_{40\%}$ equilibrium yield in 2007.

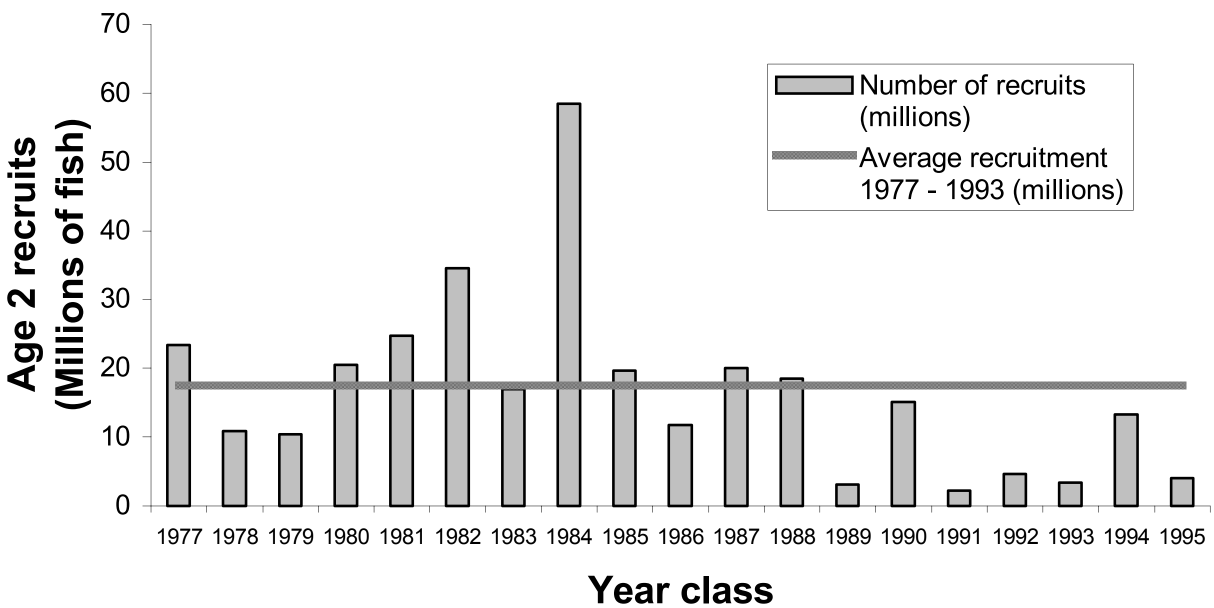

Figure 6-16. Number of recruits for year classes 1977 through 1995 and average recruitment for year classes 1977 through 1993 from the age structured model for Gulf of Alaska northern rockfish.

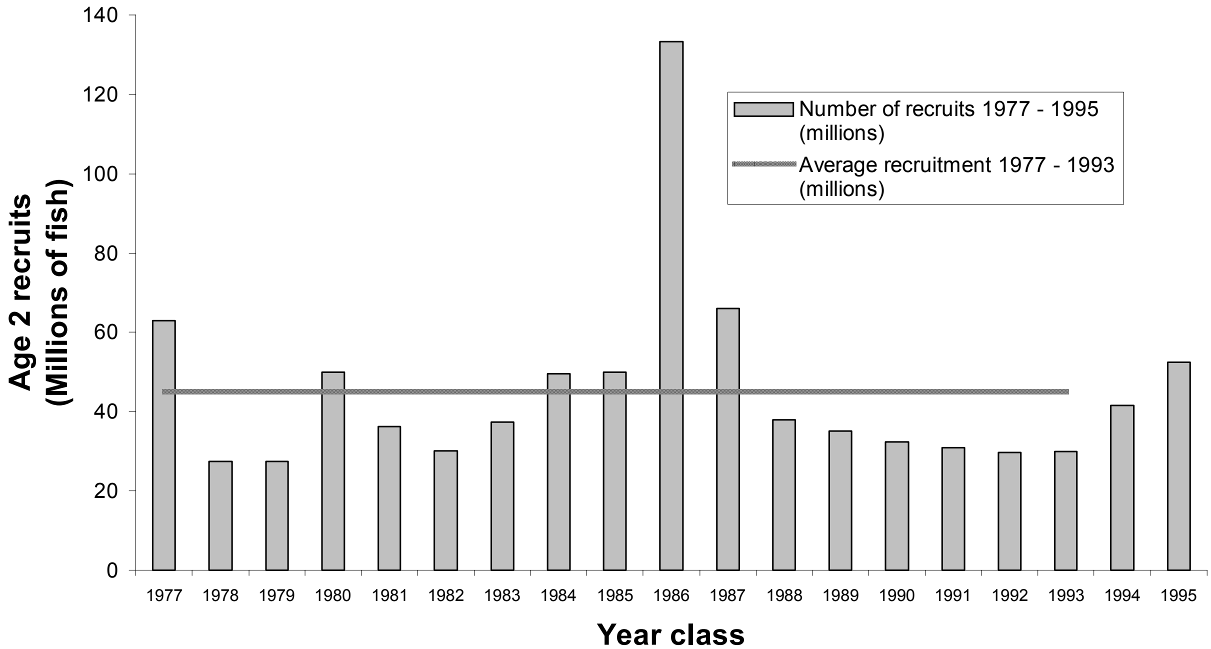

Figure 6-17. Number of recruits for year classes 1977 through 1995 and average recruitment for year classes 1977 through 1993 from the age structured model for Gulf of Alaska Pacific ocean perch.

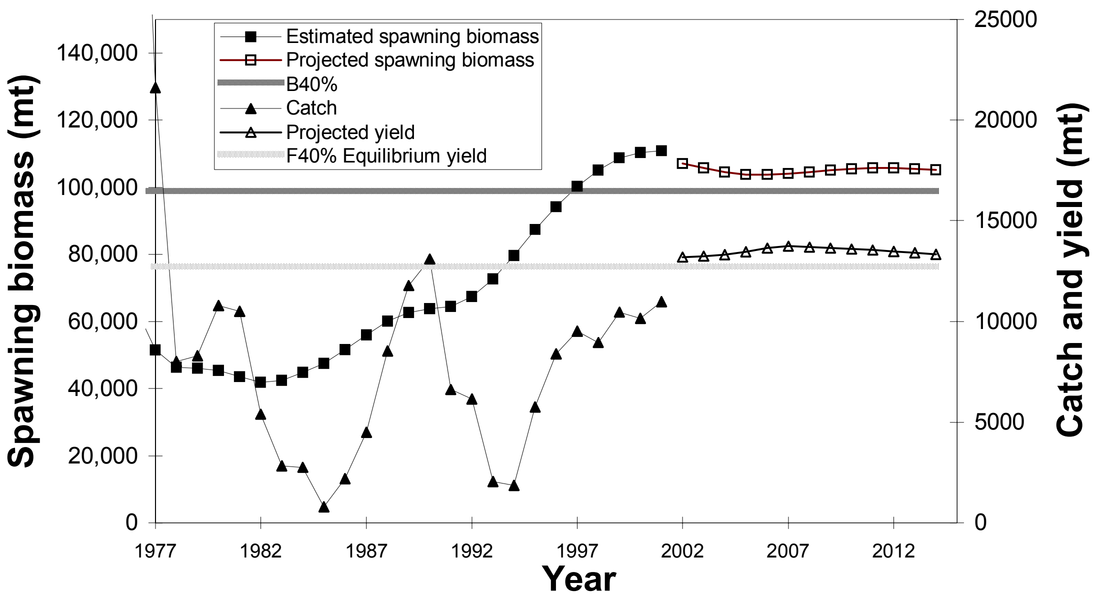

Figure 6-18. Recent trend and short term projection of spawning biomass, catch, and yield for Pacific ocean perch in the Gulf of Alaska.